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ART. XII.—*On the Measurement of the Pressure of Fired Gunpowder in its Practical Applications;* by WILLIAM E. WOODBRIDGE, M.D.

EARLY in the history of scientific gunnery the pressure of the gases generated by the combustion of gunpowder was made the subject of inquiry and experiment. Gen. Antoni of the Sardinian army, writing about the year 1785, narrated experiments on this subject, and stated that fine war-powder fired in a cylindric cavity half an inch in diameter and height, with no other opening for escape than the vent through which it was fired, exerted a pressure of from 1900 to 1400 atmospheres. This he deduced from the weight required to close the orifice of the eprouvette against the force of the explosion.

Count Rumford, in his experiments made in 1793, on the same subject, used an apparatus in which the escape of gas by the vent was prevented; the powder being fired by heating the closed end of a tube filled with it and communicating with the interior of his eprouvette. The pressure of the gases was measured by the means before referred to. The capacity of his eprouvette was about 25·5 grains of powder. With this apparatus he experimented on the force exerted by different charges from one grain upward, and from the results constructed an empirical formula, expressing very nearly the relation of the indicated expansive force of the gases to their density. The maximum

force of fired gunpowder he deduced from that estimated sufficient for the rupture of his eprouvette, which was burst by a charge filling its cavity, and concluded it to be not less than 54750 atmospheres. Although his conclusions have not always been received as rigorously correct, and some must be considered to be very erroneous, the experiments have ever since been regarded as furnishing important data, and have been made the subject of careful analysis, especially by Piobert, with reference to the circumstances of practice.

The principles on which to estimate the strength of hollow cylinders were not well understood at the time of Count Rumford's experiments; and the strength of his eprouvette was not more than one-tenth of that which he assigned to it. It does not, however, necessarily follow that the estimated bursting pressure must be reduced in the same ratio, since the relations of successive rupture to time are but imperfectly known.

The following experiment seems to show that the extreme force of gunpowder fired in small quantities does not exceed 6200 atmospheres. I enclosed in a hollow cylinder of cast-steel $1\frac{1}{2}$ inch in exterior diameter and $\frac{1}{4}$ inch in diameter interiorly, 20 grains of Hazzard's Kentucky rifle powder, which filled, loosely, the cavity. This was fired by a flash of powder penetrating through the aperture of a valve (of steel) opening inward, but designed to prevent the escape of gas outward. The cylinder was not ruptured, and being put under water, no gas was found to escape. (The weight of the instrument was too great to test the loss of gas by my scales.) On pressing in the valve by means of a screw, an abundance of gas escaped, carrying with it the odor of sulphuretted hydrogen. The seat of the valve was found to remain perfect, a fact which when compared with a former trial in which the gases escaped in consequence of a slight defect of the valve, is presumptive proof of its immediate action. The residuum was found to weigh 10·45 grains. The calculated strength of the cylinder would be equal to an internal pressure of about 93000 lbs. per square inch, or 6200 atmospheres of 15 lbs.

In the experiments above mentioned, the quantities of powder employed were small and the circumstances under which it was exploded were very different from those attending the firing of it in practice. Desirous of ascertaining the actual pressures sustained by fire-arms of different calibres, when fired with charges variously modified, by a method more exact than the deductions from these experiments afforded, I was led to devise the plan which will now be presented, together with some account of such experiments as have already been made in accordance with it.

I proposed to ascertain the pressure of the gases evolved by the combustion of gunpowder, by including in the cavity within

which the pressure was restrained, a *piezometer** which by registering the compression of the oil which it contained, should indicate the pressure to which it was exposed. The piezometer used in the experiments is a small cylindrical vessel of steel, inclosing a quantity of oil which receives the pressure of the fluid by which it may be surrounded through the medium of a piston which will move inward a distance proportioned to the amount of compression. To the piston is attached a stem of wire, projecting inward, and receiving on its side the pressure of a fine point, which, when the piston is moved, makes a line on the stem, equal in length to the distance through which the piston moves. In order that the mark may be more distinctly visible, the stem is coated with a thin film of black varnish. A partial rotation of the piston, after the adjustment of the quantity of oil, inscribes a transverse line on the stem, from which to measure the one denoting the compression. The length of the mark is measured under the microscope by means of a rule divided into $\frac{1}{1000}$ths of an inch. The details of the construction of the piezometer are arranged with reference to obtaining as great capacity and as great length of stroke as its exterior dimensions would permit—to fixing the proper relation between the area of the piston, the capacity of the instrument and the pressures to which it was to be subjected, and to its being easily filled with oil, and the quantity adjusted without including air.

The experiments on the compressibility of oil necessary to determine the pressure per square inch corresponding with a given length of stroke, at a given temperature, were carefully made. The amount of compression was subject to actual inspection, up to pressures of 10,000 lbs. per square inch. The oil submitted to trial was enclosed in an instrument of glass consisting of a bulb and graduated tube. The scale upon the tube was marked by means of a dividing-machine, and the capacities of its divisions were equal, so far as determined by a careful examination with columns of mercury, of different lengths. The capacity of each division was equal to one part in 3762·2 of the volume of the oil at 60° Fahr. To the bore of the tube (0·038 in., in diameter) was fitted an iron piston, packed by a ring of mercury occupying a groove turned in its edge. This arrangement was found to favor accurate observation, and to answer its purpose well in all respects. The instrument was enclosed in a strong tubular receiver, having windows of glass, through which it could be inspected. The windows are truncated cones, having their bases inward, and are fitted to conical cavities in opposite sides of the receiver. A rack and pinion, worked by a little shaft passing through the side of the receiver, serve to bring all

* The use of the word *piezometer* to denote an instrument for the measurement of pressure instead of compression, certainly accords with its derivation.

parts of the graduated tube successively in view. The receiver was connected by tubes to a compressing pump and to a pressure-guage. The pressure was measured by weights suspended so as to press directly on the valve of the gauge, over its centre, the relation between the pressure per square inch and the weight on the valve having been previously determined by a comparison with the pressure of a column of mercury fifty-two feet in height.

The precautions for the safety of the observer consisted in viewing the progress of compression through the strong plate glass eyes of a mask, and a small aperture in a plate of iron, interposed between them and the windows of the receiver.

The compression at pressures above 10,000 lbs. per square inch was ascertained by the use of the steel piezometer enclosed in a receiver of cast-steel, the motion of the piston being registered by the mark on the stem, as already explained.

At a pressure of 10,000 lbs. per square inch and temperature of 60° Fahr., the apparent compression of the oil, (disregarding that of the glass,) was 0·03059 its original volume being 1. At lower pressures, the compression indicated was nearly proportional to the pressure applied, though its rate decreases somewhat as the latter increases. This modification continues when the pressure is above 10,000 lbs. per square inch, but before it is raised to 20,000 lbs. per square inch, the degree of compression augments more rapidly than the pressure.

At 50° the compression of the oil was less regular in its ratio to the pressure employed, being greater as that was increased—suggesting the idea of the solidification of some of the more easily congealable portions of the oil.

To state at length all the considerations relative to the application of the piezometer which has been described, to the measurement of the pressure of fired gunpowder would extend this paper too far. It is however necessary to mention the influence of the change of temperature consequent on rapid condensation upon the amount of compression produced by any given force, the only circumstance, probably, modifying in an appreciable degree the correspondence between the pressure indicated by a stroke of the piezometer produced by slow compression, and that indicated by a mark of equal length produced by the action of fired gunpowder. When the compression is very slowly conducted, the change in the specific heat of the oil due to its condensation effects no observable alteration in its temperature, for it readily imparts its surplus heat to the bodies with which it is in contact. But if the compression be effected suddenly, any decrease in the specific heat of the liquid must be accompanied by a corresponding rise of temperature, and the compression produced in the latter case will be less, by the amount of the expansion which would, under that pressure, be

due to the elevation of temperature mentioned, than that produced by the same force slowly applied. The actual amount of this difference has not been ascertained, but data which lack the precision necessary to exact results, indicate that the correction due to this cause, which increases with both depression of temperature, and increase of pressure, is not unimportant. No attempt has been made however, to introduce this correction into the results subsequently presented of the experiments with the piezometer. The subject has been reserved in hope of future experiments, for which apparatus has been partially prepared.

In the fall of 1852 a piezometer was constructed on the plan which has been described, and was used, to test its working, for a few firings, in a 4 pdr. gun at Perth Amboy, N. J. In Feb., 1853, assistance was granted me from the U. S. Ordnance Department for testing my plan, and the subject was referred to Major Alfred Mordecai, with whom I had the pleasure and honor to be associated in making the experiments thus authorized, which, however, on account of various hindrances, were not undertaken until the winter of 1854–5.

Two six-pounder guns, one of iron and the other of brass, were used in the experiments. The diameter of the bore of each was, at the seat of the shot, 3·69 in., very nearly. The powder used was Dupont's cannon-powder, made in 1837. The shot were strapped to sabots of poplar (whitewood) of the full size of the bore unless otherwise specified. The firing was performed at Washington Arsenal, D. C. The oil used in the piezometer in all these experiments was of the same kind as that used in the experiments on compression, (unbleached winter-strained sperm oil,) being portions of the same mass.

In the first trials, the piezometer, covered with a case of paper to protect it from the heat attending the explosion, was attached by screwing to the bottom of the bore of the gun, occupying a place in the centre of the charge, but the screw was twice broken off, and this mode of using the instrument, which was originally adopted to avoid injuring the gun so as to render it unserviceable, was exchanged for the following.

The new piezometer was enclosed in a hollow plug of steel screwed into the side of the gun so that the cavity of the plug communicated with the bore of the gun. A leather case surrounded the instrument to protect it against injury from the shock of firing, and the remaining space within the cavity of the plug was filled with oil, which was retained by a disc of cork or leather loosely closing the communication with the bore. This arrangement was used in all the subsequent firing with cannon, and was entirely satisfactory. The length of the piezometer was 2·5 inches, its diameter 0·7 inch, and the diameter of its piston 0·252 in. The adjustment of the quantity of oil in

the instrument was made at the temperature at which the gun was fired. In the brass gun several holes were made for receiving the instrument at different distances (specified in the table) from the bottom of the bore. When not in use, these holes were closed by plugs fitted to each.

In the experiment with the musket barrel, a part of the breech-end, in the rear of the charge, was made to serve as a substitute for the cavity of the screw plug, in receiving the piezometer.

The experiments are to be regarded altogether as preliminary trials, but they are not, I hope, without interest and value. The following table presents the most interesting of the results.

Experiments on the pressure of fired Gunpowder.

GUN.	Powder.		Shot.		Dist'nce of piezomet'r fr m bott'm of bore.	Temperature of gun	Pressure pr. square inch.	Remarks.
	Weig't.	Height.	Weight, (strap'd.)	Diam.				
	lbs.	in.	lbs.	in.	in.	Fahr.	lbs.	
Iron 6 pdr.	1·25	3·5	6·40	3·58	(3·25)	56° 5	9640	Piezomet'r attach'd to the bottom of the bore.
	"	"	6·32	"	"	54°	10140	
	"	3·42	6·33	"	1·5	55° 5	14260	Powder without cartridge bags.
	"	3·35	6·33	"	"	50°	16070	
	"	3·42	6·39	"	"	54°	149·0	
	1·5	4·0	6·32	"	"	53°	17870	
	"	"	6·33	"	"	50°	18630	
	"	"	6·29	"	"	47°	17960	
Brass 6 pdr.	"	4·55	6·31	"	1	59°	20810	In this and subsequent firings, powder in cartr'ge bags.
	"	"	6·37	"	"	58°	20630	
	"	4·35	6·35	"	"	58°	19810	
	"	4·55	6·36	3·575	4	53°	16510	Mean of 3 rounds.
	"	"	6·34	"	7·8	50°	9575	Mean of 2 rounds.
	"	"	6·39	"	11·8	44°	7740	Mean of 3 rounds.
	"	"	6·38	"	15·8	52°	9570	" " "
	"	"	6·29	"	23·8	50°	8760	" " "
	"	"	6·33	"	31·8	"	6930	" " "
	"	"	6·36	"	39·8	"	5380	" " "
	"	"	6·34	"	47·8	"	5910	" " "
	"	4·48	6·11	"	1	"	16260	Mean of 2 rounds. Naked balls.
	"	4·65	0	...	"	"	5480	
	2·0	6·05	0	...	"	"	9780	
	3·0	8·8	0	...	"	"	14820	
	2·0	5·65	6·36	3·575	"	"	20640	Mean of 2 rounds.
	3·0	8·85	6·43	"	"	"	22220	
Iron 6 pdr.	1·5	4·38	12·16	3·66	1·5	"	20480	Cylinders equal to 2 balls.
	"	"	12·14	"	"	"	20780	" " "
	"	"	12·15	"	"	60°	20970	" " "
	grains.	in.	grs.	in.			lbs.	
Musket.	70	0·7	666	0·675	0	60°	2730	Expanding ball.
	110	1·18	420*	·65	0	"	3820	*Round ball and paper as for cartridge.
	310	3·55	464*	·675	0	"	15170	2d proof charge.
	389	4·2	" *	"	0	"	18500	1st proof charge.

In the first two experiments recorded in the preceding table the orifice of the piezometer was $3\frac{1}{4}$ inches from the bottom of

the bore, and was covered but ¼ inch deep with powder—the orifice facing toward the muzzle of the gun. The momentum of the gases rushing forward in the explosion seems to have relieved the instrument from a part of the pressure sustained by the sides of the bore at the same distance from the bottom.

The variations of pressure sustained by the gun when fired with charges very nearly the same, are greater, as might be expected, than the variations of initial velocity imparted to the ball under similar circumstances. When the combustion of the powder takes place with more than average rapidity the pressure in the first instants of the explosion is augmented, but its action on the ball is not so well sustained as in the case in which the combustion is more slow and consequently longer continued.

The following table of initial velocities of 6 pdr. balls, extracted from a table in Major Mordecai's "Second Report" of his experiments on gunpowder, will serve for the comparison.

Initial velocities of balls fired from a 6 pdr. gun.

Powder.		Shot.		Initial	
Weight.	Height.	Weight.	Diam.	Velocity.	
lbs.	in.	lbs.	in.	ft.pr.sec'd.	
1·5	4·8	6·11	3·58	1594	
1·5	4·8	6·15	"	1580	
1·5	4·9	6·13	"	1553	
1·5		6·26	"	1538	Fixed ammunition.
1·5		6·37	"	1·98	
1·5		6·3	"	1520	

ART. XIII.—*Description of the Wax-paper process employed for the Photo-Meteorographic Registrations at the Radcliffe Observatory;* by WILLIAM CROOKES, Esq.*

1. BEFORE attempting to select from the numerous Photographic processes, the one best adapted to the requirements of Meteorology, it was necessary to take into consideration a number of circumstances, comparatively unimportant in ordinary operations.

To be of any value, the records must go on unceasingly and continuously:

1st. Therefore, the process adopted must be one combining sharpness of definition, with extreme sensitiveness, in order to mark accurately the minute and oftentimes sudden variations of the instruments.

* From the Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in the year 1854, under the superintendence of Manuel J. Johnson, M.A., Radcliffe Observer. Vol. XV. Oxford: 1856.

2nd. To avoid all hurry and confusion, it is of the utmost importance that the prepared paper or other medium, be of a kind capable of retaining its sensitiveness for several days.

3rd. The contraction which paper undergoes during the numerous operations to which it is subject in most processes, (in general rather an advantage than otherwise,) is here a serious objection; for this reason, the experiment first tried, of transferring to paper the image received on collodion preserved sensitive by the nitrate of magnesia process, was a failure.

4th. Strong contrast of light and shade, and absence of half tint, unfortunately so common amongst ordinary photographic pictures, is in this case no objection.

5th. It is essential to preserve the original results in an accessible form; and for this reason, the daguerreotype process, admirably as it seems to answer other requisites, is obviously not the one best suited to our purpose.

Lastly, the whole operation should if possible be so easily reducible to practice, that with a very small share of manipulatory skill, the loss of even a day's record would be impossible.

2. Bearing these conditions in mind, on looking over the photographic processes with which I was acquainted, that known as the wax-paper process, first described by M. Le-Gray, seemed peculiarly applicable. In sharpness it might be made to rival collodion; and although generally stated to be slow in its action, I had no doubt that its sensitiveness could be easily increased to the required degree.

Of all paper processes, I believed it to be one of the most free from contraction, either during the time it is undergoing the action of the light, or in any subsequent stage. Its chief superiority, however, consisted in its capability of remaining sensitive for so long a time, that it is of little consequence whether the sensitive sheets be a day or a week old. Then the comparative slowness of the development, which has always been looked upon as one of its weak points, would be in this case a positive advantage, as dispensing with that care and attention which must always be bestowed on a quickly developing picture.

In addition to all these recommendations, it was a process to which I had paid particular attention, and consequently the one in which I might naturally hope to meet with the greatest amount of success.

3. The general outline of the process does not differ materially from that which I published some years back in "Notes and Queries," vol. vi, p. 443; but as that account was written for practical photographers, the details of the manipulations were brief. It has therefore been thought advisable, that while describing again the whole process, with the addition of such modifications as the end in view requires, I should also give a fuller

description of the manipulation, as may render it more serviceable to those who have not hitherto paid attention to photography in its practical details. This must be my excuse, if to some I seem unnecessarily prolix. None but a practical photographer can appreciate upon what apparently trivial and unimportant points success in any branch of the art may depend.

It may not be without service, if, before entering into the practical details of the process, I say a few words respecting the most advantageous way of arranging a photographic laboratory, together with the apparatus, chemicals, &c., which are of most frequent use.

Among those requisites, which may be almost called absolute necessaries, are gas, and a plentiful supply of good water, as soft as can be procured.

4. The windows and shutters of the room should be so contrived as to allow of their either being thrown wide open for purposes of ventilation, or of being closed sufficiently well to exclude every gleam of daylight; and the arrangement should admit of the transition from one to the other being made with as little trouble as possible.

5. A piece of very deep orange-colored glass, about two feet square, should be put in the window, and the shutter ought to be constructed so as to allow of the room being perfectly darkened, or illuminated, either by ordinary daylight, or daylight which has been deprived of its photographic rays, by filtering through the orange glass. The absorbing power of this glass will be found to vary very considerably in different specimens, and I know of no rule but experience to find out the quality of any particular sample; the best plan is to select from a good stock one of as dark a color as possible. The proper color is opaque to the rays of the solar spectrum above the fixed line E.

6. The best source of heat is unquestionably gas. It will be as well, however, to have a fire-place in the room, as, in some cases, a gas stove will be inapplicable. There should be gas burners in different parts of the room for illumination at night; and also an arrangement for placing a screen of orange glass in front of each.

Several rough deal benches should be put up in different parts of the room, with shelves, drawers, cupboards, &c. The arrangement of these matters must of course depend upon the capabilities of the room.

7. The following apparatus is required. The quantities are those that we have found necessary in this Observatory.

Eight dishes.
Eight mill board covers.
Three brushes for cleaning dishes.
A vessel for melting wax.

Two gauze burners.
One box iron.
Filtering paper.
A still for water.
One platinum, and three bone spatulas, (flat paper knives).
Six funnels.
One funnel stand.
Pint, half pint, one ounce, and one drachm, measures.
Three glass flasks.
Boxes for holding paper.
Scales and weights.
Sponge, glass rods, stoppered bottles, &c.

8. The dishes may be made of glass, porcelain, or gutta percha. Glass and porcelain are certainly cleaner than gutta percha; but for general use the latter is far preferable, as with it there is no risk of breakage, and the bottom of the dish can be made perfectly flat, which is a great advantage. These dishes should be made of sufficient length to allow of a margin of about half an inch at each end when the paper is in; and the shape should be made as nearly square as possible, by arranging them to take two or three sheets side by side.

The gutta percha should be of a good thickness, otherwise it will bend and give way, if it be moved when full of liquid. The depth must depend upon the size of the dish, and the purpose for which it is intended. The dishes in use here accomodate three sheets of paper side by side; they are fifteen inches square, and one inch and a half deep. I think, however, for some purposes, where they are not wanted to be moved about much, (i. e. those for holding the bath of hyposulphite of soda for fixing,) the depth might be advantageously increased to two inches and a half. Each dish ought to be reserved for a particular solution, and should have a piece of mill board a little longer than itself for a cover.

9. The brushes for cleaning the dishes are of two sorts; a common scrubbing brush will be found the best for all parts but the corners, and for these another kind must be used, having a handle about a foot long, at the end of which are tufts of stiff bristles, projecting about three quarters of an inch, and radiating on all sides, forming a ball about two inches and a half in diameter. Hardly any dirt will be found capable of resisting this brush, if it be pressed into a corner, and twisted round several times. The dishes ought always to be put away clean, as the dirt is much more difficultly removed if allowed to dry on.

10. When a dish is to be cleaned, if it be of glass or porcelain, strong nitric acid must be poured into it; if of gutta percha, it should be filled with a strong solution of cyanid of potassium. After soaking for half an hour or an hour, according to the state

of the dish, the liquid is to be returned into the bottle, (both the nitric acid and the cyanid can be used several times,) the dish rinsed out with water, and then well scrubbed in every part with the brushes; afterwards it is to be washed several times in common water, once with distilled water, and then placed in a slanting position against a wall, face downwards, to drain on clean blotting paper.

11. The vessel in which the wax is melted, must be contrived so as never to allow of its reaching a higher temperature than 212° Fahr., or decomposition of the wax might ensue. I have found the most convenient apparatus to be, a tin vessel 15 inches square and 4 inches deep, having a tray which holds the wax fitting into it, about 1 inch deep. The under vessel is to be half filled with water, and by keeping this just at the boiling temperature, the wax above will soon become liquid.

12. The best source of heat is that known as the gauze gas burner, it being free from smoke or dust, and not liable to blacken anything placed over it. It consists of a common argand burner fixed on a rather low and heavy iron stand, which is surmounted by a copper or brass cylinder 5 inches in height and 2 inches wide, having a piece of wire gauze of 900 meshes to the square inch fastened over the top. By connecting this burner by means of vulcanised indian rubber tubing to the gas pipe, it can be moved about the table to any convenient position. The mixture of gas and air formed inside the cylinder, is to be lighted above the wire gauze; it burns over this with a large and nearly colorless but intensely hot flame.

13. The most convenient form of iron is the ordinary box iron, made hot by heaters inside; perhaps it might be improved in shape by having the end not quite so pointed, but this is not of much consequence. Some operators recommend facing the bottom with a plate of silver; this is very expensive, and seems to me to be attended with no advantage whatever.

14. For the purpose of absorbing the excess of wax from the surface of the sheet, I should recommend the ordinary white wove blotting paper, medium thickness. But this is not sufficiently free from impurities to serve either for drying the sensitive sheets, or for filtering; for this purpose, the fine filtering paper (not the Swedish) employed in quantitative chemical operations is the best.

15. The distilled water being one of those substances upon the purity of which success will in a great measure depend, it will be found much safer to distil it on the premises, especially as the quantity required is trifling. A convenient size for the still is about two gallons; it may be procured ready made, with worm &c. complete, of any large dealer in chemical apparatus. It will be found far more economical both in time and trouble,

to heat the water over a charcoal or coke fire, in preference to using gas for this purpose.

16. A platinum spatula is a most necessary instrument in almost every operation; the best size is 4 inches long, $\frac{1}{2}$ an inch wide at one end, and $\frac{3}{8}$ at the other, the corners being rounded off, it should be of a sufficient substance to prevent its being easily bent. Its chief use is, to raise one corner of the sheets to allow of their being held between the finger and thumb, for the purpose of removing from one dish to another, as, previous to fixing, none of the solutions should come in contact with the fingers.

During the fixing and subsequent washing, bone spatulas will be found very useful; but after having been in contact with hyposulphite of soda, they must be carefully kept away from any of the previous baths, or black stains will infallibly ensue.

17. The funnels may be either of glass or porcelain; it will be found useful to have several of different sizes, from two inches diameter, up to six inches. A convenient stand for them may be made of a piece of flat board, with circular holes, about half the diameter of the funnels employed, drilled into it, and supported upon four legs about eight inches high. The paper used for filtering should be the finest of the two sorts of blotting paper mentioned above (14). The filters can either be cut from the sheet as wanted, or they may be obtained ready cut in packets.

The measures should be of glass, graduated, the pint and half pint into ounces, the ounce measure into drachms, and the drachm measure into minims; they should be rather long in proportion to their width.

The Florence oil flasks, which can be obtained for a trifle at any warehouse, will be found to answer every purpose, nearly as well as the more expensive German flasks. They must be cleansed thoroughly from the adhering oil; this may be done by boiling in them, over the gauze gas burner, a strong solution of ordinary washing soda, and afterwards well rinsing out with water.

18. It will be found indispensable, where there are many operations going on at the same time, and many different sheets of paper in various stages of progress, to have a separate box or division to hold the paper in each of its stages. The plan I have found most convenient, is to obtain several mill-board boxes, the fronts of which will fall flat when the lid is lifted up, similar to those used by stationers for holding letter paper, &c.: they can be made to hold two or three piles of sheets side by side.

The scales and weights need not be of any great accuracy. A six inch beam capable of turning to half a grain, when loaded with 500 grains in each pan, will be all that is requisite; the

pans must be of glass, and the weights should consist of a set of grain and a set of drachm weights.

A sponge will be found useful for wiping up any of the solutions that may have been spilt on the bench. Solid glass stirring rods of about the thickness of a quill, and six or eight inches long, and a small wedgewood pestle and mortar, are of great service in many of the operations.

Stoppered bottles should be employed for all the solutions; and too much care cannot be taken to label each bottle accurately and distinctly.

19. Besides the above apparatus, the following materials and chemicals are requisite. A rough estimate is also given of their relative consumption in three months.

Photographic paper, 270 sheets, or 112 square feet.
Four pounds of wax.
Three ounces of iodid of potassium
Three ounces of bromid of potassium.
Four ounces of nitrate of silver.
Two ounces of glacial acetic acid.
Four ounces of gallic acid.
One pint of alcohol.
Seven pounds of hyposulphite of soda.
Half a pound of cyanid of potassium.
Half a pint of concentrated nitric acid.
Eighteen gallons of distilled water.

20. The selection of a good sample of paper for the basis on which the sensitive material is to be formed is of great importance, as any imperfection will be a source of annoyance in every stage of the process, and will hardly fail to show itself on the finished picture. The paper, which from numerous experiments I have found to be superior to any other, is that known as Canson's thin photographic paper. This is manufactured with great care, and is in general very uniform in quality.

It will be found by far the most advantageous plan, when used on a scale like the present, to order it of some wholesale stationer cut to the requisite dimensions. The size of the sheets in use here is $4\frac{5}{8}$ inches by $12\frac{1}{2}$ inches*. Hitherto Messrs. Hallifax and Co. 319, Oxford Street, have supplied us with the paper of this size.

21. I am indebted to Mr. Barclay of Regent Street, wax bleacher, for much valuable information concerning wax and its adulterations, and for an extensive assortment of waxes of all

* This is a most inconvenient size, as it involves the cutting of more than one third of the paper to waste. The admirably ingenious arrangement of Mr. Ronald's, was not made with the view of employing Canson's paper; or it would doubtless have been contrived to accomodate sheets of a size which could be cut with less waste, such as $4\frac{1}{4}$ by 13 inches, or $4\frac{5}{8}$ by $11\frac{1}{4}$ inches.

kinds, and in every degree of purity: also to Mr. Maskelyne, for a valuable series of the chemical bodies of which the various waxes are composed; by means of these, I have been enabled to examine the effect produced by saturating the paper with bees wax from different countries, Myrica wax, Canauba wax, China wax, spermaceti, ethal, stearic acid, stearin, palmitic acid, palmitin, paraffin, and various oils.

22. I find that the action of the wax is purely mechanical, almost the only difference of effect produced by any of the above bodies, widely as they vary in their chemical nature, arising from a difference in their physical properties.

Stearin, palmitin, and most of the oils, are too greasy in their nature to be advantageously employed. The fatty acids do not make the paper in the least greasy, but they injure the transparency. China wax has almost too high a melting point, and gives a crystalline structure to the paper. Spermaceti also is too crystalline. Paraffin, ethal, and the waxes, produce very good results; of these bees wax is the only one that would be practically available for this purpose. It should be free from stearin, stearic acid, tallow, &c.; the presence of a little spermaceti does not much interfere, but as its price differs little from that of pure wax, it is not so common an adulteration as the other cheaper substances.

23. It will be unsafe to use the wax in the form of round thin tablets, about 4 inches in diameter, in which it is usually met with, as in this state it is generally adulterated to the extent of *at least* 50 per cent.

As an article of commerce, it is next to impossible to obtain small quantities of wax sufficiently pure to be relied upon. The only way I can recommend is to apply to one of the well known large bleachers, and trust to them for supplying the article in a state of purity. Whenever I have found it necessary to make such applications, my request has always been acceded to in the most cordial manner, and every information has been given with the utmost readiness.

24. The other chemicals, (with the exception of the strong nitric acid, which any retail druggist will supply, and the water, which had best be distilled on the premises,) should be ordered direct from some manufacturing chemist, as otherwise, unless the operator have a sufficient knowledge of chemistry to be able to detect any inferiority, there is danger of not having the articles sufficiently pure.

The iodid and bromid of potassium should be ordered *purified*.

The nitrate of silver should be crystallized, not in sticks; it ought to be perfectly dry, and have no smell, acid or otherwise.

There are usually two varieties of glacial acetic acid to be met with; the purest must be used; it should be perfectly free from

any empyreumatic odor, and must cause no turbidity when mixed with a solution of nitrate of silver, e.g. in making the exciting bath (42).

The gallic acid should be as nearly white in color as possible.

Especial care should be taken to have the alcohol good; it should be 60° over proof, and of specific gravity 0·83. On evaporating a few drops on the palm of the hand, no smell should be left behind, nor should it, under the same circumstances, leave any stain on a sheet of white paper.

25. The hyposulphite of soda will be found one of the articles most difficult to obtain pure; there is a large quantity at present in the market, having little else of the salt but the name, and is of course totally unfit for use; if there be the least doubt about its purity, it should be tested in the following manner:—

Weigh out accurately 10 grains of nitrate of silver, dissolve this in half an ounce of distilled water; then add 4 grains of chlorid of sodium (common salt) also dissolved in water. On mixing these two solutions together, a white curdy precipitate of chlorid of silver will fall down. Next add 22 grains of the hyposulphite of soda, and allow it to stand for about ten minutes, stirring occasionally with a glass rod. If at the end of that time the chlorid of silver has dissolved, the hyposulphite of soda may be considered as pure. A greater or less amount of residue will indicate roughly the degree of impurity.

26. The cyanid of potassium is usually met with in the form of hard white lumps; they will be found quite pure enough. It is very useful in removing stains formed by nitrate of silver on the fingers, &c., but the greatest care must be taken in its employment, as it is a most energetic poison; its use in cleaning the dishes from silver stains has been pointed out above (10).

27. The first operation to be performed is to make a slight pencil mark on that side of the photographic paper which is to receive the sensitive coating. If a sheet of Canson's paper be examined in a good light, one of the sides will be found to present a finely reticulated appearance, while the other will be perfectly smooth; this latter is the one that should be marked. Fifty or a hundred sheets may be marked at once, by holding a pile of them firmly by one end, and then bending the packet round, until the loose ends separate one from another like a fan; generally all the sheets lie in the same direction, therefore it is only necessary to ascertain that the smooth side of one of them is uppermost, and then draw a pencil once or twice along the exposed edges.

28. The paper has now to be saturated with white wax. The apparatus for this purpose has been previously described (11.) The wax is to be made perfectly liquid, and then the sheets of paper, taken up singly and held by one end, are gradually low-

ered on to the fluid. As soon as the wax is absorbed, which takes place almost directly, they are to be lifted up with rather a quick movement, held by one corner, and allowed to drain until the wax, ceasing to run off, congeals on the surface. When the sheets are first taken up for this operation, they should be briefly examined, and such as shew the water mark, contain any black spots,* or have any thing unusual about their appearance, should be rejected.

29. The paper in this stage will contain far more wax than necessary; the excess may be removed, by placing the sheets singly between blotting paper (14), and ironing them; but this is wasteful, and the loss may be avoided by placing on each side of the waxed sheet two or three sheets of unwaxed photographic paper, and then ironing the whole between blotting paper; there will generally be enough wax on the centre sheet to saturate fully those next to it on each side, and partially, if not entirely, the others. Those that are imperfectly waxed may be made the outer sheets of the succeeding set. Finally, each sheet must be separately ironed between blotting paper, until the glistening patches of wax are absorbed.

30. It is of the utmost consequence that the temperature of the iron should not exceed that of boiling water. Before using, I always dip it into water until the hissing entirely ceases. This is one of the most important points in the whole process, but one which it is very difficult to make beginners properly appreciate. The disadvantages of having too hot an iron, are not apparent until an after stage, while the saving of time and trouble is a great temptation to beginners. It is to a neglect of this point that I am inclined to attribute most of the faults so commonly laid to the charge of this beautiful process; such as gravelly appearance, or want of smoothness in the lights, and quick decomposition in the developing solution.

31. A well waxed sheet of paper, when viewed by obliquely reflected light, ought to present a perfectly uniform glazed appearance on one side, while the other should be rather duller; there must be no shining patches on any part of the surface, nor should any irregularities be observed on examining the paper with a black ground placed behind; seen by transmitted light, it will appear opalescent, but there should be no approach to a granular structure. The color of a pile of waxed sheets is slightly bluish.

32. The paper, having undergone this preparatory operation, is ready for *iodizing;* this is effected by completely immersing it in an aqueous solution of an alkaline iodid, either pure or mixed with some analogous salt.

* These spots have been analyzed by Mr Malone; he finds them to consist, not of iron, as is generally supposed, but of small pieces of brass. I have also examined them myself with a like result.

One would think that in no part of the photographic operation, would greater unanimity exist, than on the composition of the iodizing bath; but on this subject, strangely enough, no two persons seem to think alike. The formulæ for this bath are nearly as numerous as the operators themselves, and some of them show not a little ingenuity in the manner in which substances apparently the most unphotographic have been pressed into service.

33. The results of numerous experiments, which I need not mention here, had convinced me, that for ordinary purposes, iodid of silver *per se* was the best sensitive surface for receiving an image in the Camera; but on making use of that body in these operations, (by employing pure iodid of potassium in the bath,) I was surprised to meet with results, for which I was at first unable to account. A little consideration, however, showed me the direction in which I was to look for a remedy. The experiments which had led me to prefer iodid of silver as a sensitive surface, had all been performed with sunlight, either direct, or more frequently in the form of diffused daylight. In this case, however, coal gas was the source of light; and if, as was very probable, there were any great difference in the quality of the light from these two sources, the superiority of iodid over the bromid or chlorid of silver would still be a matter for experiment.

34. A comparison of the spectra of the two kinds of light showed a very marked difference; while in sunlight the spectral rays which are around and above the fixed line G, (the indigo and higher rays) are so intense and numerous, as completely to overpower the small space between and about F and G, (the blue and upper portion of the green,) a part of the spectrum which affects bromid more than iodid of silver; in gaslight, the case was quite different. The great bulk of photographic rays was found to lie within the limits of the visible spectrum, and consequently the photographic action of this light was likely to be far more energetic on bromid than on iodid of silver. These suppositions were fully borne out by experiment: on introducing a little bromid of potassium into the iodizing bath, the change was very apparent. It requires a certain proportion to be observed between the two to obtain the best results. If the iodid of potassium be in excess, the resulting silver salt will be wanting in sensitiveness, requiring a comparatively long development to render an image visible; while, if the bromid be in excess, there will be a great want of vigor in the impression, the picture being red and transparent. When the proportion between the two is properly adjusted, the paper will be extremely sensitive, the picture presenting a vigorous black appearance, without the least approach to red. The addition of a chlorid was found to

produce a somewhat similar effect to that of a bromid, but in a less marked degree. As no particular advantage could be traced to it, it was not employed.

35. I have also tried most of the different forms of organic matter, which it is customary to add to this bath, but I cannot recommend them; the most that can be said is, that some of them do no harm. At first I thought a little isinglass might be an improvement, as it instantly removes the greasiness from the surface of the paper, and allows the iodid of potassium to penetrate more readily. Unfortunately, however, it interferes with the most important property of this process, that of remaining sensitive for a long time.

36. I think the best results are obtained, when the iodid and bromid are mixed in the proportion of their atomic weights; the strength being as follows:

Iodid of potassium . . .	582·5 grains.
Bromid of potassium . .	417·5 grains.
Distilled water	40 ounces.*

When the two salts have dissolved in the water, the mixture should be filtered; the bath will then be fit for use.

37. At first, a slight difficulty will be felt in immersing the waxed sheets in the liquid without enclosing air bubbles, the greasy nature of the surface causing the solution to run off. The best way is to hold the paper by one end, and gradually to bring it down on to the liquid, commencing at the other end; the paper ought not to slant towards the surface of the bath, or there will be danger of enclosing air bubbles; but while it is being laid down, the part out of the liquid should be kept as nearly as possible perpendicular to the surface of the liquid; any curling up of the sheet when first laid down, may be prevented by breathing on it gently. In about ten minutes, the sheet ought to be lifted up by one corner, and turned over in the same manner; a slight agitation of the dish will then throw the liquid entirely over that sheet, and another can be treated in like manner.

38. The sheets must remain soaking in this bath for about three hours; several times during that interval, (and especially if there be many sheets in the same bath,) they ought to be moved about and turned over singly, to allow of the liquid penetrating between them, and coming perfectly in contact with every part of the surface. After they have soaked for a sufficient time, the sheets should be taken out and hung up to dry; this is conveniently affected by stretching a string across the

* While giving the above as the calculated quantities, I do not wish to insist upon their being adhered to with any extreme accuracy. An error of a few grains on either side would I believe be without any perceptible effect on the result.

room, and hooking the papers on to this by means of a pin bent into the shape of the letter S. After a sheet has been hung up for a few minutes, a piece of blotting paper, about one inch square, should be stuck to the bottom corner to absorb the drop, and prevent its drying on the sheet, or it would cause a stain in the picture.

39. While the sheets are drying, they should be looked at occasionally, and the way in which the liquid on the surface dries, noticed; if it collect in drops all over the surface, it is a sign that the sheets have not been sufficiently acted on by the iodizing bath, owing to their having been removed from the latter too soon. The sheets will usually during drying assume a dirty pink appearance, owing probably to the liberation of iodine by ozone in the air, and its subsequent combination with the starch and wax in the paper. This is by no means a bad sign, if the color be at all uniform; but if it appear in patches and spots, it shows that there has been some irregular absorption of the wax, or defect in the iodizing, and it will be as well to reject sheets so marked.

40. As soon as the sheets are quite dry, they can be put aside in a box for use at a future time. There is a great deal of uncertainty as regards the length of time the sheets may be kept in this state without spoiling; I can speak from experience as to there being no sensible deterioration after a lapse of ten months, but further than this I have not tried.

Up to this stage, it is immaterial whether the operations have been performed by daylight or not; but the subsequent treatment, until the fixing of the picture, must be done by yellow light (5).

41. The next step consists in rendering the iodized paper sensitive to light. Although, when extreme care is taken in this operation, it is hardly of any consequence when this is performed; yet in practice, it will not be found convenient to *excite* the paper earlier than about a fortnight before its being required for use. The materials for the exciting bath are nitrate of silver, glacial acetic acid, and water. Some operators replace the acetic acid by tartaric acid; but as I cannot perceive the effect of this change except in a diminution of sensitiveness, I have not adopted it. It is of little importance what be the strength of the solution of nitrate of silver; the disadvantages of a weak solution are, that the sheets require to remain in contact with it for a considerable time before the decomposition is effected, and the bath requires oftener renewing; while with a bath which is too strong, time is equally lost in the long-continued washing requisite to enable the paper to keep good for any length of time. The quantity of acetic acid is also of little consequence.

42. In the following bath, I have endeavored so to adjust the proportion of nitrate of silver, as to avoid as much as possible both the inconveniences mentioned above,

Nitrate of silver	300 grains.
Glacial acetic acid	2 drachms.
Distilled water	20 ounces.

The nitrate of silver and acetic acid are to be added to the water, and when dissolved, filtered into a clean dish (10), taking care that the bottom of the dish be flat, and that the liquid cover it to the depth of at least half an inch all over; by the side of this, two similar dishes must be placed, each containing distilled water.

43. A sheet of iodized paper is to be taken by one end, and gradually lowered, the marked side downwards, on to the exciting solution, taking care that no liquid gets on to the back, and no air bubbles are enclosed.

It will be necessary for the sheet to remain on this bath from five to ten minutes; but it can generally be known when the operation is completed by the change in appearance, the pink color entirely disappearing, and the sheet assuming a pure homogeneous straw color. When this is the case, one corner of it must be raised up by the platinum spatula, lifted out of the dish with rather a quick movement, allowed to drain for about half a minute, and then floated on the surface of the water in the second dish, while another iodized sheet is placed on the nitrate of silver solution; when this has remained on for a sufficient time, it must be in like manner transferred to the dish of distilled water, having removed the previous sheet to the next dish.

44. A third iodized sheet can now be excited, and when this is completed, the one first excited must be rubbed perfectly dry between folds of clean blotting paper (14), wrapped up in clean paper, and preserved in a portfolio until required for use; and the others can be transferred a dish forward, as before, taking care that each sheet be washed twice in distilled water, and that at every fourth sheet the dishes of washing water be emptied, and replenished with clean distilled water; this water should not be thrown away, but preserved in a bottle for a subsequent operation (49).

45. The above quantity of the exciting bath, will be found quite enough to excite about fifty sheets of the size here employed, or 3000 square inches of paper. After the bulk has been exhausted for this purpose, it should be kept, like the washing waters, for the subsequent operation of developing (49).

Of course these sensitive sheets must be kept in perfect darkness. Generally, sufficient attention is not paid to this point. It should be borne in mind, that an amount of white light, quite harmless if the paper were only exposed to its action for a few

minutes, will infallibly destroy it if be allowed to have access to it for any length of time; therefore, the longer the sheets are required to be kept, the more carefully must the light, even from gas, be excluded; they must likewise be kept away from any fumes or vapor.

46. Experience alone can tell the proper time to expose the sensitive paper to the action of light, in order to obtain the best effects. However, it will be useful to remember, that it is almost always possible, however short the time of exposure, to obtain some trace of effect by prolonged development. Varying the time of exposure, within certain limits, makes very little difference on the finished picture; its principal effect being to shorten or prolong the time of development.

Unless the exposure to light has been extremely long, (much longer than can take place under the circumstances we are contemplating,) nothing will be visible on the sheet after its removal from the instrument, more than there was previous to exposure; the action of the light merely producing a latent impression, which requires to be developed to render it visible.

47. The developing solution in nearly every case consists of an aqueous solution of gallic acid, with the addition, more or less, of a solution of nitrate of silver.

An improvement on the ordinary method of developing with gallic acid, formed the subject of a communication to the Philosophical Magazine for March, 1855, where I recommend the employment of a strong alcoholic solution of gallic acid, to be dilluted with water when required for use, as being more economical both of time and trouble than the preparation of a great quantity of an aqueous solution for each operation.

48. The solution is thus made: put two ounces of crystallized gallic acid into a dry flask with a narrow neck; over this pour six ounces of good alcohol, (60° over proof,) and place the flask in hot water until the acid is dissolved or nearly so. This will not take long, especially if it be well shaken once or twice. Allow it to cool, then add half a drachm of glacial acetic acid, and filter the whole into a stoppered bottle.

49. The developing solution which I employ for one set of sheets, or 180 square inches, is prepared by mixing together ten ounces of the water that has been previously used for washing the excited papers (44), and four drachms of the exhausted exciting bath (45); the mixture is then filtered into a perfectly clean dish, and half a drachm of the above alcoholic solution of gallic acid poured into it. The dish must be shaken about until the greasy appearance has quite gone from the surface; and then the sheets of paper may be laid down on the solution in the ordinary manner with the marked side downwards, taking particular care that none of the solution gets on the back of the paper, or it will

cause a stain. Should this happen, either dry it with blotting paper, or immerse the sheet entirely in the liquid.

50. If the paper has been exposed to a moderate light, the picture will begin to appear within five minutes of its being laid on the solution, and will be finished in a few hours. It may however sometimes be requisite, if the light has been feeble, to prolong the development for a day or more. If the dish be perfectly clean, the developing solution will remain active for the whole of this time, and when used only for a few hours, will be quite clear and colorless, or with the faintest tinge of brown; a darker appearance indicates the presence of dirt. The progress of the development may be watched, by gently raising one corner with the platinum spatula, and lifting the sheet up by the fingers. This should not be done too often, as there is always a risk of producing stains on the surface of the picture. I prefer allowing the development to go on, until the black is rather more intense than ultimately required, as it is generally toned down in the fixing bath.

51. As soon as the picture is judged to be sufficiently intense, it must be removed from the gallo-nitrate, and laid on a dish of water, (not necessarily distilled). In this state it may remain until the final operation of fixing, which need not be performed immediately, if inconvenient. After being washed once or twice, and dried between clean blotting paper, the picture will remain unharmed for weeks, if kept in a dark place.

52. The *fixing bath* is composed of a saturated solution of hyposulphite of soda diluted with its own bulk of water. Into this the sheets are to be completely immersed, until the whole of the yellow iodid of silver has been dissolved out. This operation need not be performed by yellow light; daylight is much bettter for shewing whether the picture be entirely fixed. This will take from a quarter of an hour to two hours, according to the time the bath has been in use.

It will be well not to put too many sheets into the bath at once, in order to avoid the necessity of turning them over to allow the liquid to penetrate every part.

When fixed, the sheet if held up between the light and the eye, will present a pure transparent appearance in the white parts.

The fixing bath gradually becomes less and less active by use, and then its action is very energetic on the dark parts of the picture, attacking and dissolving them equally with the unchanged iodid. When this is the case it should be put on one side, (not thrown away,) and a fresh bath made.

53. After removal from the fixing bath, the sheets must be well washed. In this operation, the effect depends more upon the quantity of water used, than upon the duration of the immer-

sion. When practicable it is a good plan to allow water from a tap to flow over the sheets for a minute or two, and having thus got rid of the hyposulphite of soda from the surface, to allow them to soak for about ten minutes in a large dish of hot water.

54. They are then to be dried by hanging up by a crooked pin, as after iodizing. When dry, they will present a very rough and granular appearance in the transparent parts; this is removed by melting the wax, either before a fire, or, what is far better, by placing them between blotting paper, and passing a warm iron over them; by this means, the white parts will recover their original transparency.

55. The picture, arrived at this stage, may be considered finished, as far as is requisite for the purposes of measurement and registration; sometimes, however, it may be necessary to multiply copies, for the purpose of transmitting to other Meteorological Observatories facsimiles of the records, or at least of those containing any remarkable phenomena. I will therefore now detail the method of printing photographic positives from these negatives, premising that the process does not differ materially from that usually adopted.

56. The only extra piece of apparatus required, is a *pressure frame;* which consists essentially of a stout piece of plate glass in a frame, with an arrangement for screwing a flat board, the size of the glass, tight against it. Though apparently very simple, some care is required, when the frame is a large one, in arranging the screw and board at the back, so as to obtain an equal pressure all over the surface; unless this is done, the glass will be very liable to break. The pressure frames supplied to us by Messrs Newman and Murray, 122, Regent Street, are unexceptionable in this respect. The board should of course be well padded with velvet, and the lateral dimensions of the glass should be the same as those of the gutta percha dishes (8).

57. The extra chemicals required for this process, are chlorid of sodium, and chlorid of gold. Generally speaking, for the former, common table salt will be found quite pure enough; but as the quantity required is but small, it will perhaps be found better to obtain some of the recrystallized salt along with the other chemicals.

The chlorid of gold is merely required for an artistic effect. Many persons object to the reddish brown appearance of ordinary photographic positives; the addition of a little chlorid of gold to the fixing bath converts this into a rich brown or black; the trifling quantity required removes any objection to its use on the score of expense.

58. I prefer using the same kind of paper for positives as for negatives (20). Messrs Canson manufacture a thicker paper, which is generally called positive paper, but I think the thin is

far preferable; the surface is smoother, and the various solutions penetrate much better.

59. The first operation which the paper has to undergo is *salting*: the bath for this purpose consists of

Chlorid of sodium . . .	100 grains
Distilled water	40 ounces.

Filter this into a clean dish, and completely immerse the sheets, marked as directed (27). This is best done by laying them gently on the surface of the liquid, and then pressing them under by passing a glass rod over them; as many sheets as the dish will hold may be thus immersed one after the other. Allow them to soak for about ten minutes, then lift and turn them over in a body; afterwards they may be hung up to dry (38), commencing with the sheet which was first put in. When dry, they may be taken down and put aside for use at any future time. The sheets in drying generally curl up very much; it will therefore be found convenient in the next process, if the salted sheets, before being put away, have been allowed to remain in the pressure frame, tight, for about 24 hours. This makes them perfectly flat.

60. The exciting bath is composed of

Nitrate of silver	150 grains.
Distilled water	10 ounces.

After filtering, pour the solution into a clean dish; and then lay the sheets, salted as above, on the surface, face downwards, gently breathing on the back, if it be necessary, to counteract the tendency to curl up; let them remain on this bath for about 10 minutes, and then hang up to dry (38).

61. This exciting bath will serve for nearly 100 sheets; it will then be better to put it on one side (64), and make a new bath. It is not advisable to excite more positive sheets than will be likely to be required in the course of a week, for they gradually turn brown by keeping, even in the dark, and lose sensitiveness. They will, however, keep much better, if pressed tight in the pressure frame, and thus protected from the air.

62. When a positive is to be printed from a negative, let the glass of the pressure frame be perfectly cleansed and free from dust on both sides, then lay the negative on it, with its back to the glass. On it place a sheet of positive paper, with its sensitive side down. Then, having placed over, as a pad, several sheets of blotting paper, screw the back down with sufficient force to press the two sheets into close contact, but of course not so as to endanger the glass. Now place the frame in the sun, so that the light can fall perpendicularly on the glass, and allow it to remain there until it is judged to have been exposed long enough.

63. No rule can be laid down for the proper time of exposure; it will depend upon the quality of the light, and intensity of the negative; some pictures being completed in a few minutes, others requiring upwards of half an hour. The printing should always go on until the picture is several shades darker than ultimately required. A very little experience will enable the operator to judge so well of the quality of the light, as hardly ever to have a failure. If the two sheets of paper be stuck together in two or three places at the edges with small pieces of gummed paper, the frame can be removed to the dark room, and the progress of the sheets examined; but this is always attended with some danger, for unless they are replaced without having been shifted one from the other, there will be a double image.

64. As soon as the picture is considered to be printed sufficiently deep, it has to be fixed.

The fixing bath consists of

Saturated solution of hyposulphite of soda	10 ounces.
Water	30 ounces.

This bath will be found to fix the pictures perfectly, but they will generally be of a reddish tint; if it be thought desirable to obtain the pictures of some shade of dark brown, or black, it will be necessary to employ a bath made as follows;

Saturated solution of hyposulphite of soda	10 ounces.
Water.	10 ounces.
Exhausted positive exciting solution (61)	10 ounces.

Mix these together and then add the following;

Water	10 ounces,
Chlorid of gold	20 grains;

taking care in mixing to pour the solution of gold into the solution of hyposulphite, and not the latter into the former, or another decomposition will be produced.

Pour this mixture into a dish, and lay the positive carefully on it, face downwards. As soon as it is thoroughly damp, (which may be known by its becoming perfectly flat after having curled up,) immerse it totally in the liquid.

65. The pictures should not be too crowded in the bath, as they are very apt to become irregularly colored in places where the hyposulphite has not had free access during the whole of the time. When first put in, the color will change to a light brown, and in the course of some time, varying from ten minutes to two or three hours, it will pass through the different shades of brown to black and purple, gradually fading in intensity during the time. It will be necessary to allow the picture to remain in this bath for ten minutes *at least* in order that it may be perfectly

fixed. After this time, its stay need only be prolonged until it has become of the desired tone and color; always remembering, that during the subsequent operation of drying, &c., it will become of a somewhat darker tint than when taken out of the fixing bath.

66. On removal from this bath, the pictures must be allowed to soak in a large quantity of cold water for ten or twelve hours. There must not be very many in the dish at a time, and the water must be changed at least three times during that interval; they must then have boiling water poured over them (of course in a *porcelain* dish) two or three times, and lastly pressed dry, between sheets of clean blotting paper (14), (these may be used several times, if dried,) and then allowed to dry spontaneously in the air. When the pressure frame is not in use, a pile of these finished positives may be put in, and kept tightly screwed up all night; by this means they will be rendered perfectly flat and smooth.

67. The picture is now complete. It must be borne in mind, however, that the light and shade are reversed by this operation, the track of the luminous image along the paper being represented by a *white* instead of by a *black* band, as in the original negative. Should it be desired to produce exact facsimiles of the negatives, it can be done by employing one of these positives as a negative, and printing other positives from it; in this way, the light and shade having been twice reversed, will be the same as in the original negative.

68. In some cases it may happen, that owing to a partial failure of gas, or imperfection in the sensitive sheet, an image may be so faint as to render it impossible to print a distinct positive. The gap that this would produce in a set of pictures may be obviated, and with very slight sacrifice of accuracy, by forming an artificial or *secondary* negative in the following manner:

69. Print a copy on positive paper, of any intensity which will show the most distinct impression; then without fixing, and with a pair of sharp scissors, accurately and carefully cut out the part corresponding to the impressed portion of the negative. Expose this piece to the light until it has become perfectly opaque, and then it can either be cemented over the imperfect original sheet, or on a clean sheet of paper, and used as an ordinary negative.

It is astonishing what accuracy and quickness in cutting even the most intricate pictures, may be obtained with a little practice; the error of the scissors is generally within the error of measurement.

ART. XIV.—*On a Zeolitic mineral (allied to Stilbite) from the Isle of Skye, Scotland;* by J. W. MALLET, Ph.D.

THE specimen to which the following description refers has been in my possession for several years, and has attached to it a label bearing the name "Hypostilbite," but analysis shows it to be a mineral quite distinct from Beudant's hypostilbite of the Faroe Islands, and differing also from both stilbite proper and epistilbite.

It occurs as a mass of minute crystals, resembling white loaf sugar, breaking easily, and crushing under the fingers into a coarsish crystalline powder. The separate grains viewed under the microscope appear as single prismatic crystals or little groups of three or four, nearly transparent, colorless, and with a pearly lustre, especially on two opposite faces,—closely resembling stilbite in fact in general appearance.

The crystalline form could not be satisfactorily made out, but seemed to be monoclinic. Hardness a little greater than that of calcite. Specific gravity =2·252.

Strong muriatic acid poured over the pulverized mineral at night had the next morning formed a distinct jelly.

On analysis the following results were obtained.

		Atoms.
Silica,	53·95	1·191—3·
Alumina,	20·13	·392—1·
Lime,	12·86	·459—1·17
Magnesia,	trace	
Potash (with a little soda),	·87	
Water,	12·42	1·380—3·52
	100·23	

Neglecting the small quantity of alkali, these numbers lead us nearly to the formula,

$$2(CaO, SiO_3)+2(Al_2O_3, 2SiO_3)+7HO,$$

which differs completely from that of stilbite, $CaO, SiO_3+Al_2O_3, 3SiO_3+6HO$, or that of epistilbite, $CaO, SiO_3+Al_2O_3, 3SiO_3+5HO$. The percentage of water is also far too small for hypostilbite.

The mineral appears to be a distinct one, and does not seem to have resulted from the gradual decomposition or change of any other; but it is perhaps scarcely desirable to add to the already numerous names of stilbite-like minerals by adopting a new one for this substance until additional analyses of these nearly related species shall permit of their more accurate classification.

Art. XV.—*On the Application of the Mechanical Theory of Heat to the Steam Engine;* by R. Clausius.

[Translated for this Journal from Pogg. Ann. xcviii, 441, by W. G.]*

1. As the change in our views on the nature and relations of heat which is now comprised under the name of the "mechanical theory of heat," had its origin in the recognized fact that heat may be employed in producing mechanical work, we might *a priori* expect that, conversely, the theory which was originated in this way would contribute to put this application of heat in a clearer light. In particular the more general points of view obtained in this way should render it possible to form a certain judgment on the particular machines which serve for this application, whether they already perfectly answer their purpose, or whether, and how far, they are susceptible of improvement.

To these principles, which hold good for all thermodynamic machines, there are to be added for the most important of them—the steam engine—some particular ones which incite us to submit it to a new investigation deduced from the mechanical theory of heat. Some important deviations from the laws which were formerly assumed as correct, or at least applied in calculation, have been found to hold good precisely for steam at its maximum density.

2. In this particular I believe that I must first remind the reader that it has been proved by Rankine and myself, that when a quantity of steam, originally at its maximum density, expands in a shell which is impermeable to heat, by pushing back with its full expansive force a movable portion of the shell, as for instance a piston, a portion of the steam must be precipitated as water, while in most previous writings on the steam engine, and among others in the excellent work of de Pambour,† the principle of Watt, that under these circumstances the steam remains precisely at its maximum density, is assumed as the basis of the reasoning.

Furthermore, in the want of accurate knowledge, it was formerly assumed, in determining the volume of the unit of weight of saturated steam at different temperatures, that steam even at its maximum density still obeys the laws of Mariotte and Gay Lussac. In opposition to this I have already shewn in my first memoir on this subject,‡ that we may calculate the volumes which a unit of weight of steam assumes at different temperatures at its maximum density, from the fundamental principles of the mechanical theory of heat, by means of the collateral assumption, *that a permanent gas when it expands at a constant temperature ab-*

* The importance of this memoir induces us to give it *in extenso* instead of attempting an abstract, which would scarcely do it justice.—W. G.

† Theorie des machines à vapeur, par le Conte F. M. G. de Pambour. Paris, 1844.

‡ Pogg. Ann., lxxix, 368.

sorbs only so much heat as is consumed in doing the external work performed, and that we find in this way many values which, at the higher temperatures at least, deviate considerably from the laws of Gay Lussac and Mariotte.

This view of the behavior of steam was not shared at that time even by authors who occupied themselves specially with the mechanical theory of heat. W. Thomson in particular contested the point. He found—even a year later in a memoir laid before the Royal Society of Edinburg—in this result, only a proof of the improbability of my collateral assumption. More recently however, he has himself, associated with J. P. Joule, undertaken to test the correctness of this assumption experimentally. They have in fact found by a series of well devised experiments conducted upon a large scale, that the assumption is so nearly correct for the permanent gases examined by them, namely, atmospheric air and hydrogen, that the variations may in most calculations be neglected. They found, however, greater variations for the non-permanent gas, carbonic acid, which they also studied. This corresponds entirely with the remark, which I added to the first mention of the assumption, that it is probably true for every gas precisely in the degree in which the laws of Mariotte and Gay Lussac find their application to the same gas. In consequence of these experiments, Thomson has now also calculated the volume of saturated steam in the same way as myself. I believe therefore that the correctness of this mode of calculation will gradually be more and more fully recognized by other physicists also.

3. These two examples will suffice to shew that the fundamental principles of the former theory of the steam engine have undergone such important changes through the mechanical theory of heat that a new investigation of the subject is necessary.

In the present memoir I have made the attempt to develop the principles of a calculation of the work of the steam engine, corresponding with the mechanical theory of heat, in which however I have confined myself to the usual forms of the steam engine without at present entering upon the more recent attempts—certainly well worthy of consideration—to apply steam in an overheated state.

In setting forth this investigation I shall only suppose as known my last published memoir* "On an altered form of the second principal theorem of the mechanical theory of heat." It is true that it will in this way be necessary to deduce a second time in a somewhat different manner some results which are no longer new, but which were obtained at an earlier period by other writers or by myself; I believe however, that this repetition will be justified by the greater unity and clearness of the whole.

I shall refer in the proper places to the papers in which these results were first communicated, as far as they are known to me.

* Pogg. Ann., xciii, 481.

4. The expression that *heat drives a machine*, is of course not to be immediately referred to the heat, but is to be understood as signifying that some substance present in the machine, in consequence of the changes which it undergoes by heat, sets the parts of the machine in motion. We will call this substance the heat-utilizing substance (*den die Wirkung der Wärme vermittelnden Stoff*).

If now a continually acting machine be in uniform action, all the changes which occur take place periodically, so that the same condition in which the machine, with all its single parts, is found at a particular time, regularly recurs at equal intervals. Consequently the heat-utilizing substance must be present in the machine in equal quantity at such regularly recurring instants and must be in a similar condition. This condition may be fulfilled in two different ways.

In the first place, one and the same quantity of this substance originally existing in the machine may always remain in it, in which case the changes of condition which the substance undergoes during the action of the machine must take place in such a manner that at the end of every period it again returns to its initial condition, and then begins again the same cycle of changes.

In the second place, the machine may each time give off, externally, the substance which has served during one period to produce the action, and in its place may take up again from without the same quantity of substance of the same kind.

5. This last process is the more usual one in machines applied in practice. It occurs, for instance, in the caloric air machines constructed up to the present time, inasmuch as after every stroke the air which has moved the piston in the cylinder is driven into the atmosphere, and an equal quantity of air is supplied from the atmosphere, through the feeding cylinder. The same is the case in steam engines without condensers in which the steam passes from the cylinder into the atmosphere, while, to supply its place, a fresh portion of water is pumped from a reservoir into the boiler.

Furthermore, at least a partial application is also made in steam engines with condensers of the usual arrangement. In these the water condensed from the steam is partly pumped back into the boiler, but not wholly, because it is mixed with the cold water used for condensation, and a portion of this consequently also passes into the boiler. The portion of the condensed water not again applied must be thrown out with the rest of the water of condensation.

The first process has recently been applied in those steam engines which are worked by two different vapors, as for instance by water and the vapor of ether. In these the steam is condensed only by contact with the metallic tubes which are inter-

nally filled with liquid ether and is then completely pumped back into the boiler. In like manner the ether vapor is condensed in metallic tubes which are only externally surrounded by cold water, and is then pumped back into the first mentioned space which serves for the evaporation of the ether. In order to keep up a uniform action, therefore, it is only necessary to add as much water or ether as escapes through the joints from imperfections in the construction.

6. In a machine of this kind in which the same mass is always employed anew, the different changes which the mass undergoes during a period, must, as mentioned above, form a closed cycle, or according to the nomenclature which I have chosen in my former paper, a *circular process* (kreisprocess). Those machines, on the other hand, in which a periodical taking up and throwing out of masses occurs, are not necessarily subject to this condition. They may however also fulfill it when they separate the masses again in the same condition in which they have taken them up.

This is the case with steam engines with condensers, in which the water is thrown out from the condenser in the liquid state, and with the same temperature with which it passed from the condenser into the boiler.*

In other machines the condition at the exit is different from that at the entrance. The caloric air machines, for instance, even when they are provided with regenerators, force the air into the atmosphere with a higher temperature than it previously had, and the steam engines without condensers take up the water as a liquid and let it pass out again as a vapor. In these cases, no complete circular process takes place, it is true; nevertheless we may always imagine a second machine joined to that which is really present, which takes up the mass from the first machine, brings it in any way into the initial condition, and then first lets it escape. The two machines together may then be regarded as a single machine which again satisfies the above condition. In many cases this completion may be performed without producing thereby too great a complication of the investigation. Thus for instance we may imagine a steam engine without condenser, replaced by one with a condenser whose temperature is 100°, if we only assume that the first is fed with water at 100°.

Hence it appears that, upon the supposition that the machines which do not in themselves fulfill the condition, may in this way be completed for the purpose of investigation, we may apply to all thermo-dynamic machines the theorems which hold good for the circular process, and in this way we arrive at some conclusions which are quite independent of the particular nature of the processes taking place in the several machines themselves.

* The cooling water which passes into the condenser cold and out of it warm, is not here taken into consideration, since it does not belong to the heat-utilizing substance, but serves only as a negative source of heat.

7. I have represented in my former memoir the two principal theorems which hold good for every circular process, by the following equations.

$$(\text{I}) \qquad Q = A \,.\, W$$

$$(\text{II}) \qquad \int \frac{dQ}{T} = -N,$$

in which the letters have the same signification as they have there, namely—

A is the equivalent of heat for the unit of work.

W represents the external work done during the circular process.

Q signifies the heat communicated to the changeable body during the circular process, and dQ an element of the same by which a quantity of heat taken from the body is considered as negative communicated heat. The integral of the second equation extends over the whole quantity Q.

T is a function of the temperature which the variable body has at the moment at which it takes up the element of heat dQ, or, should this body have different temperatures in its different parts, of the temperature of the part which takes up dQ. As to the form of the function T, I have shewn in my previous memoir that it is probably nothing else than the temperature itself, when this is estimated from the point which is determined by the reciprocal value of the coefficient of expansion of an ideal gas, and which must lie in the neighborhood of $-273°$ C., so that when the temperature estimated from the freezing point is denoted by t, we have

$$(1) \qquad T = 273 + t.$$

In future I shall employ the magnitude T always with this signification, and call it briefly the absolute temperature, remarking however that the conclusions arrived at do not in their essence depend upon this assumption, but remain valid even if we regard T as a still undetermined function of the temperature.

Finally, N signifies the equivalent value of all the uncompensated changes occurring in the circular process.*

* A species of uncompensated transformations requires here a special notice. The sources of heat which are to communicate heat to the variable body must have higher temperatures than this last, and conversely those which are to communicate to it negative heat, or to take away heat from it, must have lower temperatures. At every exchange of heat between the variable body and a source of heat, there is an immediate passage of heat from a body of a higher temperature to one of a lower temperature, and herein lies an uncompensated transformation which is so much the greater, the more different the two temperatures are. Whether these uncompensated transformations, in the determination of which not only the changes of condition of the variable body, but also the temperatures of the sources of heat applied come into consideration, are embraced in N or not, depends upon the signification which we attribute to the temperature occurring in equation (II). If we understand by this the temperature of the *source of heat* belonging to the element dQ, these transformations are included in N. If however we understand by it as is above determined, and as it will be understood in this whole memoir, the temperature of the *variable body*, these transformations are excluded from N. Furthermore a remark

8. If the process have taken place in such a manner that it may be executed inversely in the same way, $N=0$. If however there occur in the circular process one or more changes of condition which have taken place in a manner which cannot be inverted, then uncompensated transformations have come into play, and the magnitude N has an assignable value, which however can only be positive.

Among the processes to which this last finds an application, one in particular will in future be frequently discussed. When a quantity of gas or vapor expands, and in so doing overcomes a pressure corresponding to its whole expansive force, it may be again compressed by an application of the same force, in which case all the phenomena with which the expansion was accompanied occur in an inverse manner. This is however no longer the case when the gas (or vapor) does not meet in expanding the full resistance which it could overcome, when, for instance, it streams from one vessel, in which it was under a greater pressure, into another in which a less pressure is exerted. In this case a compression is not possible under the same circumstances under which the expansion took place.

The equation (II) gives us a means of determining the sum of all the uncompensated transformations in a circular process. As however a circular process may consist of many single changes of condition of a given mass, of which some have taken place in an invertable, and others in an uninvertable manner, it is in many cases of interest to know how much each single one of the last has contributed to the production of the whole sum of uncompensated transformations. For this purpose imagine that the mass, after the change in condition which we wish in this way to investigate, is brought back by any invertable process to its original condition. In this way we obtain a small circular process to which equation (II) is as applicable as to the whole. If we know also the quantities of heat which the mass has taken up during the same, and the temperatures belonging to it, the negative integral $-\int\frac{dQ}{T}$ gives the uncompensated change which has occurred in it. Now as the restoration which has taken place in an invertable manner can have contributed nothing to

must be made on the minus sign before N, which does not occur in my previous memoir in the same equation. This difference depends only on the fact that there the positive and negative sense of the quantities of heat is chosen otherwise than here. There a quantity of heat taken up by the variable body was calculated as negative because it is lost for the source of heat, here on the other hand it is considered as positive. All the elements of heat contained in the integral hereby change their sign, and with them at the same time the whole integral, consequently in order that the equation should remain correct notwithstanding the change, it was necessary to change the sign on the other side also.

its increase, this expression represents the uncompensated transformation occasioned by the given change of condition.

If in this manner we have investigated all the parts of the whole circular process which are not invertable, and thereby determined the values N_1, N_2, &c., which must all singly be positive, their sum gives the magnitude N with reference to the whole circular process, without its being necessary to bring into the investigation those parts of which we know that they are invertable.

9. If we now apply equations (I) and (II) to the circular process which takes place in the thermo-dynamic machine during a period, we see in the first place that if the whole quantity of heat which the mediating substance has taken up during this time is given, then the work is also determined immediately by the first equation, without its being necessary to know the nature of the processes themselves of which the circular process consists. In similar generality we may, by the combination of the two equations, determine the work from other data also.

We will assume that the quantities of heat which the variable body receives one after the other, as well as the temperatures which it has at the reception of each, are given, and that there is only one temperature over and above, whose magnitude is not known *à priori*, at which a quantity of heat is still communicated to, or, if it be negative, taken from, the body. Let the sum of all the known quantities of heat be Q_1, and the unknown quantity of heat Q_0.

Then resolve the integral in equation (II) into two parts, of which one extends only over the known quantity of heat Q_1, and the other over the unknown quantity Q_0. In the last part the integration may be directly executed, since T has in it a constant value T_0, and gives the expression

$$\frac{Q_0}{T_0}.$$

The equation (II) becomes hereby

$$\int_0^{Q_1} \frac{dQ}{T} + \frac{Q_0}{T_0} = -N,$$

whence follows

$$Q_0 = -T_0 \cdot \int_0^{Q_1} \frac{dQ}{T} - T_0 \cdot N.$$

Further we have according to equation (I), as, for our case, $Q = Q_1 + Q_0$:

$$W = \frac{1}{A}(Q_1 + Q_0).$$

If we substitute in this equation for Q_0 the value just found, we have

$$(2) \qquad W=\frac{1}{A}\left(Q_1-T_0\int_0^{Q_1}\frac{dQ}{T}-T_0 . N\right).$$

If we assume specially that the whole circular process is invertable, according to the above $N=0$, and the foregoing equation becomes

$$(3) \qquad W=\frac{1}{A}\left(Q_1-T_0\int_0^{Q_1}\frac{dQ}{T}\right).$$

This expression is only distinguished from the previous one by the term $-\frac{T_0}{A} . N$. Since N can only be positive this term can only be negative, and we see from this, which is also easily deduced from a direct consideration, that we obtain the greatest possible amount of work under the conditions above determined, when the whole circular process is invertable, and that the quantity of work is diminished by every circumstance which causes one of the special processes occurring in the circular process to be uninvertable.

Equation (2) leads accordingly to the sought value of the work in a manner which is directly opposed to the usual one, inasmuch as we do not, as formerly, determine singly the quantities of work performed during the different processes and then add them together, but set out from the maximum work, and subtract from it the losses of heat which have arisen from the single incomplete parts of the process.

If we make the limiting condition with respect to the communication of the heat that the whole quantity of heat Q_1 is communicated to the body at a determined temperature T_1, the portion of the integration embracing this quantity of heat may be at once executed, and gives

$$\frac{Q_1}{T_1},$$

by which equation (3), which holds good for the maximum of the work, takes the following form,

$$(4) \qquad W=\frac{Q_1}{A}\cdot\frac{T_1-T_0}{T_1}.$$

In this special form the equation was already deduced by W. Thomson and Rankine from the combination of Carnot's theorem, modified by me, with the theorem of the equivalence of heat and work.*

10. Before we can pass from these considerations, which hold good for all thermo-dynamic machines, to the treatment of the steam engine, some remarks with respect to the behavior of vapors at a maximum density must first be brought forward.

* Phil. Mag., July, 1851.

I have already in my former paper of 1850, on the motive power of heat, developed the equations which represent the two principal theorems of the mechanical theory of heat in their applications to vapors at a maximum density, and have applied them to deduce various conclusions.

As I have however introduced in my last memoir "on a change in the form of the second principal theorem of the mechanical theory of heat," a somewhat different mode of representing the whole subject, I consider it, as already mentioned, more advantageous for the sake of greater simplicity and breadth of view, to suppose only this last memoir as known. I will therefore again deduce in a different way the equations referred to from the results obtained in it.

In this memoir it was assumed, in order to apply the general equations first established to a somewhat more special case, that the only foreign force acting upon the variable body which deserves consideration in determining the external work, was an external pressure, the force of which was equal at all points of the surface, and whose direction was every where perpendicular to it, and that further this pressure always changed only so slowly, and consequently was at every instant only so little different from the expansive force of the body acting opposite to it, that in calculation the two might be considered as equal. If then we denote by p the pressure, by v the volume, and by T the absolute temperature of the body, which last we will introduce into the formulas instead of the temperature as estimated from the freezing point, because they take a simpler form in this way, the equations deduced for this case are as follows,

$$\text{(III)} \qquad \frac{d}{dT}\left(\frac{dQ}{dv}\right) - \frac{d}{dv}\left(\frac{dQ}{dT}\right) = A \cdot \frac{dp}{dT}$$

$$\text{(IV)} \qquad \frac{dQ}{dv} = A \cdot T \frac{dp}{dT}.$$

These equations are now to be applied to the still more special case of vapors at a maximum density.

11. Let the given mass of the substance whose vapor is to be considered be M, and let this be contained in a completely closed extensible vessel, the part m in a state of vapor, and the remaining part, $M-m$, in a fluid state. This mixed mass is now to form the variable body to which the previous equations are to be applied.

If the temperature T of the mass and its volume v—that is to say, the content of the vessel—are given, then the condition of the mass, so far as it here comes under consideration, is thereby completely determined. Since namely, the vapor by supposition always remains in contact with the liquid, and consequently at a maximum density, its condition, as well as that of the liquid,

depends only on the temperature T. It only remains to decide whether the quantity of the two parts which are present in different conditions is determined. For this purpose the condition is given, that these two parts must together exactly fill up the content of the vessel. If we therefore denote the volume of the unit of weight of steam, at its maximum density, at the temperature T by s, and that of a unit of weight of fluid by σ, we must have:

$$v = m \,.\, s + (M-m)\sigma$$
$$= m(s-\sigma) + M\sigma.$$

The quantity s occurs in what follows, only in the combination $(s-\sigma)$, and we will therefore introduce a special letter for this difference, putting

$$(5) \qquad u = s - \sigma,$$

by which the previous equation becomes

$$(6) \qquad v = m\,u + M\sigma,$$

and hence

$$(7) \qquad m = \frac{v - M\sigma}{u}.$$

By this equation, m is determined as a function of T and v, since u and σ are functions of T.

12. In order now to be able to apply equations (III) and (IV) to our case, we must first determine the quantities $\frac{dQ}{dv}$ and $\frac{dQ}{dT}$.

Let us first assume that the vessel expands so much that its content increases by dv, then a quantity of heat must be thereby communicated to the mass, which will in general, be represented by

$$\frac{dQ}{dv}\,dv.$$

Now since this quantity of heat is only consumed in the formation of vapor which takes place during the expansion, it may also be represented, if the heat of evaporation be denoted for the unit of mass by r, by the expression

$$r\,\frac{dm}{dv}\,dv,$$

and we may also put

$$\frac{dQ}{dv} = r\,\frac{dm}{dv}$$

whence, since according to (7),

$$\frac{dm}{dv} = \frac{1}{u},$$

we find

$$(8) \qquad \frac{dQ}{dv} = \frac{r}{u}.$$

If we assume in the second place, that the temperature of the mass, while the content of the vessel remains constant, is in-

creased by dT, the quantity of heat necessary, will be represented generally by

$$\frac{dQ}{dT}dT.$$

This quantity of heat consists of three portions—1. The fluid portion, $M-m$ of the whole mass, must be warmed by dT, for which purpose, if c denotes the specific heat of the liquid, the quantity of heat $(M-m)c\,dT$ is necessary.

2. The portion m in the state of vapor must in like manner be heated by dT, but will thereby at the same time be so much compressed, that for the increased temperature $T+dT$, it is again at a maximum density. The quantity of heat which must be communicated to a unit of mass of vapor during its compression, in order that it shall have at every density precisely the temperature for which this density is a maximum, we shall denote for an increase of temperature of dT, in general by $h\,dT$ in which h is a magnitude which is previously unknown as to its value, and even as to its sign. The quantity of heat necessary for our case, will hence be represented by $mh\,dT$.

3. In the process of heating, a small quantity of the previously fluid portion, passes into the state of vapor, which is represented generally by $\frac{dm}{dT}dT$, and which consumes the quantity of heat

$$r\frac{dm}{dT}dT.$$

In this, according to equation (7)

$$\frac{dm}{dT}=-\frac{v-M\sigma}{u^2}\cdot\frac{du}{dT}-\frac{M}{u}\cdot\frac{d\sigma}{dT}$$

$$=-\frac{m}{u}\cdot\frac{du}{dT}-\frac{M}{u}\cdot\frac{d\sigma}{dT},$$

by which the previous expression becomes

$$-r\left(\frac{m}{u}\cdot\frac{du}{dT}+\frac{M}{u}\cdot\frac{d\sigma}{dT}\right)dT.$$

If we add these three quantities of heat together, and put their sum equal to $\frac{dQ}{dT}dT$ we have

$$(9)\qquad \frac{dQ}{dT}=M\left(c-\frac{r}{u}\cdot\frac{d\sigma}{dT}\right)+m\left(h-c-\frac{r}{u}\cdot\frac{du}{dT}\right).$$

13. The first of these expressions for $\frac{dQ}{dv}$ and $\frac{dQ}{dT}$ must now also, as is signified in equation (III), be differentiated, the first with respect to T, and the last with respect to v. If we consider moreover that the quantity M is constant, the quantities u, σ, r,

c and h, only functions of T, and the quantity m only a function of T and v we obtain

$$(10) \qquad \frac{d}{dT}\left(\frac{dQ}{dv}\right)=\frac{1}{u}\cdot\frac{dr}{dT}-\frac{r}{u^2}\cdot\frac{du}{dT}$$

$$\frac{d}{dv}\left(\frac{dQ}{dT}\right)=\left(h-c-\frac{r}{u}\cdot\frac{du}{dT}\right)\frac{dm}{dv}.$$

or, if we put for $\frac{dm}{dv}$ its value $\frac{1}{u}$,

$$(11) \qquad \frac{d}{dv}\left(\frac{dQ}{dT}\right)=\frac{h-c}{u}-\frac{r}{u_2}\cdot\frac{du}{dT}.$$

By substituting the expressions given in (10), (11), and (8), in (III) and (IV) we obtain the sought equations, which represent the two principal theorems of the mechanical theory of heat for vapors at a maximum density, namely

$$(V.) \qquad \frac{dr}{dT}+c-h=A\,.\,u\,.\,\frac{dp}{dT}.$$

$$(VI.) \qquad r=A\,.\,Tu\frac{dp}{dT}.$$

and from the combination of the two, we also obtain

$$(12) \qquad \frac{dr}{dT}+c-h=\frac{r}{T}.$$

14. With the help of these equations we will now consider a case which will so often occur in what follows, that it is advantageous to fix, à priori, the results which refer to it.

Let it namely be assumed that the previously considered vessel with its contents of partly fluid and partly vaporized mass, changes its volume, without any heat being added to or taken from the mass. Then together with the volume, the temperature and the quantity of that portion of the mass which is present in the form of vapor will change, and besides, a positive or negative external work will be done by the heat which produces the pressure of the vapor, since in the change of volume the pressure of the enclosed vapor which is exerted in the expansion overcomes an external force, and in the compression is overcome by an external force.

Under these circumstances, the quantity of the portion m, in the form of vapor, the volume v and the work W are to be determined as functions of the temperature T.

15. If the volume and the temperature are changed by the arbitrary infinitely small quantities dv and dT, the quantity of heat, which for this purpose must be communicated to the mass, will be expressed according to the foregoing by the sum

$$r\frac{dm}{dv}\,dv+\left[(M-m)c+mh+r\frac{dm}{dT}\right]dT.$$

This sum must be equated to zero, in consequence of the condition now laid down that heat must neither be communicated to nor taken from the mass. In this way we obtain, if we simply write dm for

$$\frac{dm}{dv}dv+\frac{dm}{dT}dT,$$

the equation

$$(13) \qquad r\,dm+m(h-c)\,dT+Mc\,dT=0.$$

If we substitute in this, according to (12)

$$h-c=\frac{dr}{dT}-\frac{r}{T},$$

and again write simply dr for $\frac{dr}{dT}dT$, since r is only a function of T, we have

$$r\,dm+m\,dr-\frac{mr}{T}dT+Mc\,dT=0,$$

or $$(14) \qquad d(mr)-\frac{mr}{T}dT+Mc\,dT=0.$$

If we divide this equation by T, and remember that

$$\frac{d(mr)}{T}-\frac{mr}{T^2}dT=d\left(\frac{mr}{T}\right),$$

we obtain

$$(15) \qquad d\left(\frac{mr}{T}\right)+Mc\frac{dT}{T}=0.$$

As the specific heat of a liquid changes but slowly with the temperature, we will in what follows, always consider the quantity c as constant. Then the previous question may be integrated at once, and gives

$$\frac{mr}{T}+Mc\log T=\text{const.}$$

or if the initial values of T, r, m, be denoted by T_1, r_1, m_1,

$$(\text{VII}) \qquad \frac{mr}{T}=\frac{m_1r_1}{T_1}-Mc\log\frac{T}{T_1}.$$

By this equation, m is also determined as a function of the temperature, if r, as a function of the temperature, can be à priori considered as known.

In order to give an approximate view of the behavior of this function, I have collected together in the following table some values calculated for a particular case. It is assumed namely that the vessel at the beginning contains no liquid water, but is exactly filled with steam at the maximum density, so that in the previous equation m_1 is to be put equal to M, and let now an expansion of the vessel take place. If the vessel should be

compressed, we could not make the assumption that in the beginning no fluid water is present, because then the vapor would not remain at a maximum density, but would be overheated by the heat produced during the compression. In the expansion on the other hand, the steam remains not only at a maximum density, but a part of it is in fact condensed, and it is precisely the diminution of m produced thereby, to which the table refers. The initial temperature is assumed as 150° C., and corresponding values of $\frac{m}{M}$ are given for the times when the temperature has sunk by the expansion to 125°, 100°, etc. The temperature estimated from the freezing point is denoted by t, as heretofore, to distinguish it from the absolute temperature represented by T.

t	150°	125°	100°	75°	50°	25°
$\frac{m}{M}$	1	0·956	0·911	0·866	0·821	0·776

16. In order to express the relation between the volume v and the temperature, we have in the first place equation (6), namely $v = mu + M\sigma$. The quantity σ occurring here, which signifies the volume of a unit of weight of the liquid, changes very little with the temperature, and as besides the whole value of σ is very small with respect to u, we may with the more propriety neglect the small changes which it undergoes, and we will therefore consider σ and consequently also the product $M\sigma$ as constant. We have therefore only to determine the product mu. For this purpose we only need to substitute in the equation (VII,) for r, the expression given in (VI,) whereby we obtain

$$\text{(VIII.)} \qquad mu\frac{dp}{dT} = m_1 u_1 \left(\frac{dp}{dT}\right)_1 - \frac{Mc}{A} \log \frac{T}{T_1}.$$

The differential coefficient $\frac{dp}{dT}$ which occurs here is to be looked on as known; p itself is known as a function of the temperature, and consequently by this equation, the product mu is determined, and from it we obtain by addition of $M\sigma$ the sought quantity v.

In the following table, there is again collected a series of values of the fraction $\frac{v}{v_1}$, which are deduced from this equation, for the same case to which the foregoing table relates. For the sake of comparison, those values of $\frac{v}{v_1}$ are also added, which we should obtain if the two assumptions usually made heretofore in the theory of the steam engine were correct. (1.) that the steam

in expanding remains exactly at a maximum density, without partially precipitating, (2.) that it obeys the laws of Mariotte and Gay Lussac. According to these assumptions we should have

$$\frac{v}{v_1} = \frac{p'}{p} \cdot \frac{T}{T_1}.$$

t	150°	125°	100°	75°	50°	25°
$\frac{v}{v_1}$	1	1·88	3·90	9·23	25·7	88·7
$\frac{p'}{p} \cdot \frac{T}{T_1}$	1	1·93	4·16	10·21	29·7	107·1

17. It remains finally to determine also the work done during the change of volume. For this purpose we have generally the equation

$$(16.) \qquad W = \int_{v_1}^{v} p\,dv$$

Now according to equation (6) if σ be regarded as constant:

$$dv = d(mu)$$

whence

$$p\,dv = p\,d(mu)$$

for which we may also write

$$(17.) \qquad p\,dv = d(mup) - mu\frac{dp}{dT}dT.$$

We might put in this for $mu\frac{dp}{dT}$ the expression given by equation (VIII) and then execute the integration. We obtain the result however at once in a rather more convenient form by the following substitution. According to (VI) we have

$$mu\frac{dp}{dT}dT = \frac{1}{A} \cdot \frac{mr}{T}dT,$$

and from this by employing equation (14):

$$mu\frac{dp}{dT}dT = \frac{1}{A}\left[d(mr) + Mc\,dT\right].$$

Hence (17) becomes

$$p\,dv = d(mup) - \frac{1}{A}\left[d(mr) + Mc\,dT\right],$$

and by integrating this equation we obtain

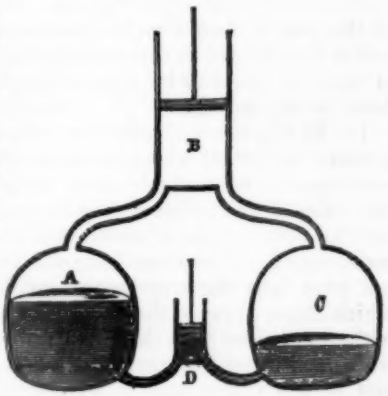
$$(IX.) \qquad W = mup - m_1u_1p_1 + \frac{1}{A}\left[m_1r_1 - mr + Mc(T_1 - T)\right]$$

whence W may be calculated, since the quantities mr and mu are already known from the foregoing equations.

I have also carried out this calculation for the above special case, whereby I have obtained the values given in the table for $\frac{W}{M}$, that is for the work done during the expansion by the unit of mass. The kilogram is selected as the unit of mass, and the kilogram-meter as the unit of work. For $\frac{1}{A}$ the value found by Joule, 423·55, is employed.* For comparison with the numbers in the table I will also add, that we obtain for the work which is done during the evaporation itself, by the steam which overcomes the external counter-pressure, in the case of which 1 kilogram of water evaporates at the temperature of 150° and under a corresponding pressure, the value 18700.

t	150°	125°	100°	75°	50°	25°
$\frac{W}{M}$	0	11300	23200	35900	49300	63700

18. We turn our attention now to the consideration of the steam engine itself. In the accompanying schematic figure, which is only intended to facilitate the general view of the whole series of processes connected with the action of a common steam-engine, let A represent the boiler, the contents of which are kept by the source of heat, at the constant temperature T_1. From this, a portion of the steam passes into the cylinder B, and forces the piston to a certain height. Then the cylinder is cut off from the boiler, and the steam contained in it, lifts the piston still higher by expansion. The cylinder is thereupon put into connexion with the space C, which shall represent the condenser. We shall assume with respect to this, that it is not kept cool by injected water but by cooling from without, which, as above remarked, produces no important difference in the results, but simplifies the consideration of the subject. Let the con-



* $\frac{1}{A}$ is the equivalent of work for the unit of heat, and the above number signifies that the quantity of heat which is able to warm 1 kilogram of water from 0° to 1°, when converted into mechanical work gives a quantity of work equal to 423·55 Kgr. M.

stant temperature of the condenser be called T_0. During the connection of the cylinder with the condenser, the piston goes back again through the whole space which it previously passed over, and thereby all the steam which did not of itself pass directly into the condenser is driven into this and is here condensed. It only remains in order to complete the cyclus of operations, to bring back into the boiler the liquid which has arisen from the condensation of the steam. This purpose is served by the small pump D, whose action is so regulated that during the ascent of the piston, it draws up exactly as much liquid from the condenser as has been brought into this last by the condensation of the steam; and this quantity of liquid is then forced into the boiler by the descent of the piston. When this has here become heated again to the temperature T_1, everything is again in the initial condition, and the same series of processes can begin anew. We have here then to deal with a complete circular process.

In common steam engines, the steam passes into the cylinder not only from one side, but alternately from both. This however produces only the difference that during an ascent and descent of the piston, two circular processes take place instead of one, and it is sufficient in this case also to determine the work for one of them in order to be able to deduce the whole work which is done during any time.

19. In this determination we will, as is customary, consider the cylinder as a shell which is impenetrable to heat, neglecting the exchange of heat which takes place during one stroke between the walls of the cylinder and the steam. The mass in the cylinder can only consist of steam at a maximum density mixed with some liquid. It is clear from the foregoing, that the steam cannot pass into the overheated condition during the expansion which takes place in the cylinder after cutting off its connection with the boiler, provided that no heat be communicated from without, but on the contrary that it must be partly precipitated, and in other processes to be mentioned farther on, which it is true might occasion a slight overheating, this is prevented by the fact that the steam in rushing into the cylinder always carries with it some liquid and remains in contact with it.

The quantity of this liquid mixed with the steam is insignificant, and as it is for the most part distributed through the steam in fine drops, and consequently can rapidly participate in the changes of temperature which the steam undergoes during the expansion, we shall make no sensible error if we consider in calculation the temperature of the whole mass in the cylinder as the same for every determined instant of time.

Furthermore, not to make the formulas too complicated at the outset, we will in the first place determine the whole work which is done by the pressure of the steam without taking into account

how much of this work is really useful, and how much on the other hand again is consumed in the machine in overcoming the friction and in moving the pumps, which are necessary for the working of the machine, beside that indicated in the figure. This part of the work may also be subsequently determined, and subtracted, as will be shown farther on.

It is moreover to be remarked with respect to the friction of the piston in the cylinder, that the work consumed in overcoming it is not to be considered as entirely lost, for by this friction heat is generated, and thereby the interior of the cylinder kept warmer than it otherwise would be, and consequently the force of the steam is increased.

Finally, as it is advantageous to learn in the first place the action of the most complete machine possible before we study the influence of the particular imperfections which naturally occur, we shall add to this preliminary consideration two suppositions which at a future time will be again given up. Namely, in the first place, that the conducting pipe from the boiler to the cylinder, and the waste-pipe from the cylinder to the condenser or to the atmosphere is so wide, or that the motion of the steam engine is so slow, that the pressure in that part of the cylinder which is in connexion with the boiler, is equal to that in the boiler itself, and in like manner, that the pressure on the other side of the piston is equal to the pressure in the condenser, or to the pressure of the atmosphere, and secondly, that no injurious space is present.

20. Under these circumstances, the quantities of work done during a circular process, may be expressed without further calculation, with the help of the results obtained above, and give a simple expression as the sum. Let the whole mass which passes during the ascent of the piston from the boiler into the cylinder, be called M, and let the part m_1 be in the form of vapor, and the part $M-m_1$ liquid. The space which this mass occupies is, if m_1 signifies the value of u belonging to T_1,

$$m_1 u_1 + M\sigma.$$

The piston is accordingly lifted as high as this space underneath it becomes free, and as this happens under the action of the pressure p_1 belonging to T_1, the work done during this first process, which we may call W_1, is

$$W_1 = m_1 u_1 p_1 + M\sigma p_1. \tag{18}$$

Let the expansion which now follows be so far continued, until the temperature of the mass enclosed in the cylinder has sunk from the value T_1 to a second given value, T_2. The work which is done hereby, which we may call W_2, is found immediately from equation (IX), if T_2 is assumed in it, as the final temperature, and also if the corresponding values are substituted for the other quantities occurring in the equation, namely:

$$(19.)\quad W_2 = m_2 u_2 p_2 - m_1 u_1 p_1 + \frac{1}{A}[m_1 r_1 - m_2 r_2 + Mc(T_1 - T_2)].$$

In the forcing down of the piston, which now begins, the mass which at the end of the expansion occupied the space

$$m_2 u_2 + M\sigma$$

is driven from the cylinder into the condenser, whereby the constant counter pressure p_0 is to be overcome. The negative work which is thereby done by this pressure is:

$$(20.)\qquad W_3 = -m_2 u_2 p_0 - M\sigma p_0.$$

While now the piston of the small pump rises so high that the space $M\sigma$ becomes free under it, the pressure p_0 which takes place in the condenser acts in its favor, and does the work

$$(21.)\qquad W_4 = M\sigma p_0.$$

Finally, at the descent of this piston, the pressure p_1 which takes place in the boiler must be overcome, and does therefore the negative work:

$$(22.)\qquad W_5 = -M\sigma p_1.$$

By the addition of these five quantities, we obtain for the whole work done during the circular process, by the pressure of the steam, or as we may also say, by the heat, which we may call W', the expression

$$(x)\quad W' = \frac{1}{A}[m_1 r_1 - m_2 r_2 + Mc(T_1 - T_2)] + m_2 u_2 (p_2 - p_0).$$

From this equation, the quantity m_2 must be eliminated. This quantity, if we substitute for u_2 the value deduced from (VI),

$$\frac{r_2}{A \cdot T_2 \left(\frac{dp}{dT}\right)_2}$$

occurs only in the combination $m_2 r_2$, and for this product equation (VII) gives the expression

$$m_2 r_2 = m_1 r_1 \frac{T_2}{T_1} - Mc\, T_2 \log \frac{T_2}{T_1}.$$

By substituting this expression we obtain an equation in which only known quantities occur on the right side, since the masses m_1 and M and the temperatures T_1, T_2 and T_0 are assumed as immediately given, and the quantities r, p and $\frac{dp}{dT}$ are supposed to be known as functions of the temperature.

21. If in equation (x) we put T_2 equal to T_1, we obtain the work for the case in which the machine works without expansion, namely:

$$(23)\qquad W' = m_1 u_1 (p_1 - p_0)$$

If on the other hand, we make the assumption, that the expansion is driven until the steam by the expansion has cooled from the temperature of the boiler to that of the condenser, which, it is true, it is not completely possible to do, but which still forms the limiting case to which we must approximate as closely as possible, we need only put $T_2 = T_0$ whereby we obtain

$$(24) \qquad W' = \frac{1}{A}\left[m_1 r_1 - m_0 r_0 + Mc(T_1 - T_0)\right].$$

If we also eliminate from this $m_0 r_0$ by means of the before-cited equation, in which also we must put $T_2 = T_0$, we have

$$(\text{XI}) \qquad W' = \frac{1}{A}\left[m_1 r_1 \frac{T_1 - T_0}{T_1} + Mc\left(T_1 - T_0 + T_0 \log \frac{T_0}{T_1}\right)\right]^*.$$

22. If we write the foregoing equation in the following form,

$$(25) \qquad W' = m_1 r_1 \frac{T_1 - T_0}{A\,T_1} + Mc(T_1 - T_0) \cdot \frac{1}{A}\left(1 + \frac{T_0}{T_1 - T_0} \log \frac{T_0}{T_1}\right),$$

the two products which occur herein, $Mc(T_1 - T_0)$ and $m_1 r_1$, represent together the quantity of heat given out by the source of heat, during a circular process. The first is namely the quantity of heat which is necessary in order to heat the mass M which comes from the condenser in the fluid state, with the temperature T_0 up to T_1, and the last represents the quantity of heat which is required to convert the portion m_1 at the temperature T_1 into steam. As m_1 is little smaller than M, the last quantity of heat is far greater than the first.

We will bring the factor belonging to $Mc(T_1 - T_0)$ into a somewhat different form, in order to be able to compare with each other more conveniently the two factors, with which these two quantities of heat are multiplied in equation (25). If then, for the sake of abbreviation, we introduce the letter z with the signification

$$(26) \qquad z = \frac{T_1 - T_0}{T_1}$$

* The foregoing equations, which represent the work under the two simplifying suppositions mentioned at the conclusion of § 19, had been developed by me a long time since, and publicly brought forward in my lectures at the University of Berlin in the summer of 1854. When later in the year 1855 the Philos. Trans. of the Roy. Soc. of London for the year 1854 appeared, I found in them a memoir of Rankine "On the geometrical representation of the expansive action of heat and the theory of thermo-dynamic engines," and was astonished to find that Rankine had arrived at the same time, quite independently and by a different process, at equations which not only in their essential contents, but also in their form, corresponded almost completely with mine, only that Rankine had not considered the circumstance that a quantity of liquid is mixed with the steam at its entrance into the cylinder. By the earlier publication of this paper the priority was lost for this part of my investigation, nevertheless the correspondence was in so far a gratification to me, as it gave me a guarantee that the mode of considering the subject employed was really a natural one.

we have

$$\frac{T_0}{T_1 - T_0} = \frac{1-z}{z}$$

$$\frac{T_0}{T_1} = 1-z$$

and we therefore obtain

$$1 + \frac{T_0}{T_1 - T_0} \log \frac{T_0}{T_1} = 1 + \frac{1-z}{z} \log (1-z)$$

$$= 1 - \frac{1-z}{z}\left(\frac{z}{1} + \frac{z^2}{2} + \frac{z^3}{3} + \text{etc.}\right)$$

$$= \frac{z}{1.2} + \frac{z^2}{2.3} + \frac{z^3}{3.4} + \text{etc.}$$

Equation (25) or (XI) thus becomes

$$(27) \quad W' = m_1 r_1 \cdot \frac{z}{A} + Mc(T_1 - T_0)\frac{z}{A} \cdot \left(\frac{1}{1.2} + \frac{z}{2.3} + \frac{z^2}{3.4} + \text{etc.}\right)$$

The value of the infinite series enclosed in the brackets which distinguishes the factor of the quantity of heat $Mc(T_1 - T_0)$ from that of the quantity of heat $m_1 r_1$, varies, as one may easily see, between $\frac{1}{2}$ and 1 while z increases from 0 to 1.

23. We may also obtain the expression for the work very easily in another way, for this last considered case in which the steam cools by expansion to the temperature of the condenser, without following singly the different processes of which the circular process consists. In this case, namely, the circular process is invertible in all its parts—we may imagine that the evaporation takes place in the condenser at the temperature T_0, and that the mass M, of which the part m_0 is vapor, and the part $(M - m_0)$ is liquid, passes into the cylinder, and lifts the piston; that then during the descent of the piston, the steam is first compressed until its temperature has risen to T_1 and is thereupon forced into the boiler, and that finally by means of the small pump, the mass M is again forced as a liquid from the boiler into the condenser, and cools to the initial temperature T_0. The substance passes here through the same states as formerly, only in inverse order. The additions or subtractions of heat take place in a contrary direction, but in the same quantity and with the same temperature as the mass, and all the quantities of work have contrary signs but the same numerical values.

Hence it follows that in this case no uncompensated transformation occurs in the circular process. We must therefore in equation (2) put $N=0$, and thereby obtain the equation already cited in (3) in which only for the sake of correspondence, W' is to be written in place of W.

$$W' = \frac{1}{A}\left(Q_1 - T_0 \int_0^{Q_1} \frac{dQ}{T}\right).$$

Q_1 signifies herein for our case, the heat communicated in the boiler to the mass M, and we have therefore

$$Q_1 = m_1 r_1 + Mc\,(T_1 - T_0).$$

In determining the integral $\int_0^{Q_1} \frac{dQ}{T}$ the two single quantities of heat contained in Q_1, $Mc\,(T_1 - T_0)$ and $m_1 r_1$ must be particularly considered. In order to execute the integration for the first, we may write the element of heat dQ in the form $Mc\,dT$, then this portion of the integral becomes

$$Mc \int_{T_0}^{T_1} \frac{dT}{T} = Mc \log \frac{T_1}{T_0}.$$

During the communication of the last quantity of heat, the temperature is constantly equal to T_1, and the portion of the integral relating to this quantity of heat is therefore simply $\frac{m_1 r_1}{T_1}$. By substituting these values, the above expression for W' becomes the following.

$$W' = \frac{1}{A}\left[m_1 r_1 + Mc(T_1 - T_0) - T_0\left(\frac{m_1 r_1}{T_1} + Mc \log \frac{T_1}{T_0}\right)\right]$$

$$= \frac{1}{A}\left[m_1 r_1 \frac{T_1 - T_0}{T_1} + Mc\left(T_1 - T_0 + T_0 \log \frac{T_0}{T_1}\right)\right]$$

and this is the same expression as that contained in equation (XI), which we have previously found by the successive determination of the single quantities of work done during the circular process.

24. Hence it follows that *if the temperatures at which the substance conveying the action of the heat takes up the heat delivered by the source or gives out heat outwardly, are considered as previously given*, then the steam engine, under the suppositions made in deducing equation (XI) is a perfect machine, inasmuch as for a definite quantity of heat communicated to it, it does as much work as, according to the mechanical theory of heat, is possible at the same temperatures.

The matter is otherwise however if we do not regard these temperatures as given à priori, but consider them as a variable element which must be taken into consideration in judging the machine. In consequence of the fact that the liquid, during its

warming and evaporation, has much lower temperatures than the fire, and that thus the heat which is communicated to it must pass from a higher to a lower temperature, there is in N an uncompensated transformation which is not reckoned in the calculation, which with the reference to making the heat useful occasions a great loss. The work which can be obtained in the steam engine from the quantity of heat, $m_1 r_1 + Mc(T_1 - T_0) = Q_1$ is, as we see from equation (27), somewhat smaller than

$$\frac{Q_1}{A} \cdot \frac{T_1 - T_0}{T_1}.$$

If therefore the same quantity of heat could be communicated to a variable body at the temperature of the fire, which may be called T', while the temperature corresponding to the subtraction of heat, remains as formerly T_0, the work possibly to be obtained in this case according to equation (4) would be represented by

$$\frac{Q_1}{A} \cdot \frac{T' - T_0}{T'}.$$

In order to be able to compare the values of these expressions in some examples, let the temperature t_0 of the condenser be fixed at 50° C., and let the temperatures 110°, 150°, and 180° C. be assumed for the boiler, of which the first two correspond about to the low pressure engine and to the common high pressure engine, and the last is to be regarded as about the limit of the temperatures used in steam engines in practice. For these cases, the fraction depending on the temperatures has the following value.

t_1	110°	150°	180°
$\frac{T_1 - T_0}{T_1}$	0·157	0·236	0·287

Whereas the corresponding value for the temperature of t' of the fire, if we assume this only at 1000° C. is 0·746.

25. It is hereby easy to perceive what S. Carnot and after him many other authors have asserted, that in order to arrange machines moved by heat more advantageously, we must principally endeavor to make the interval of temperature $T_1 - T_0$ greater. It is thus for example in the case of the caloric air machines only then to be expected that they will obtain an important advantage over steam engines, when we succeed in making them work at considerable higher temperatures than steam engines, in which the danger of explosion forbids the application of too high temperatures. The same advantage may however also be obtained with overheated steam, since as soon as the vapor is separated from the liquid, we may heat it still fur-

ther with as little danger as if it were a permanent gas. Machines which employ the steam in this condition can unite many advantages of steam engines with those of air engines, and a practical result is therefore sooner to be expected from them, than from the air engines.

In the above-mentioned machines in which, besides water, a second more volatile substance is applied, the interval $(T_1 - T_0)$ is made larger because T_0 is made lower. The idea has also suggested itself in the same manner to increase the interval on the upper side by adding a third fluid less volatile than water. The fire would then immediately evaporate the least volatile of the three substances; this, by its condensation, the second, and this the third. According to the principle it is not to be doubted that this combination would be advantageous, how great however, the practical difficulties will be which are opposed to the execution, cannot à priori be determined.

26. Besides the imperfection of the common steam engines just mentioned, which is founded in their nature itself, these machines have many other defects, which are to be attributed more to their practical construction.

One of these has already been considered in the above developments, and is comprised in equation (x), namely, that the expansion cannot by any means be carried so far that the steam in the cylinder reaches the temperature of the condenser. If we take, for instance, the temperature of the boiler at 150°, and that of the condenser at 50°, we see from the table of § 16 that for this purpose the expansion must continue to 26 times the original volume, while in reality in consequence of many evils which occur in high expansions, we usually allow it to reach only 3 or 4, and at the utmost, 10 times the volume.

Two other defects, on the other hand, have been expressly excluded in what precedes, namely, in the first place that the pressure of the steam in one part of the cylinder is less than in the boiler, and in the other part greater than in the condenser—and secondly, the presence of the injurious space.

We must therefore now enlarge our former views, in such a manner that these imperfections shall also be taken into consideration.

(To be concluded)

Art. XVI.—*Statistics of the Flora of the Northern United States;* by Asa Gray.

While engaged in the preparation of a second edition of the *Manual of the Botany of the Northern United States*, I was requested by an esteemed correspondent, upon whose judgment I place great reliance, to exhibit, in a compendious and convenient form, the elements of the flora I was occupied with. I accede to this request only because I may be presumed to possess considerable facilities for collecting and correcting a portion of the required data. But I cannot command the time needed for a proper elaboration and discussion of these materials, nor have I any special aptitude for this kind of research. I may, however, collect and arrange the principal data; for the use of those better qualified to discuss them, and to indicate their bearings upon many questions of the highest scientific interest, respecting the geographical distribution, the mutual relations, the nature, and the origin of the existing species of plants;—questions some of them so speculative or so difficult that they are not likely to be conclusively answered in our day; others more nearly within our reach; but all perhaps capable of some elucidation from the critical comparison of the flora of any one considerable region with the vegetation of other parts of the world.

The work,* which forms the basis of the following statistics of the botany of the Northern United States, has now been extended in geographical area beyond the limits of the Northern States, politically so called; inasmuch as this area includes Virginia and Kentucky, and stretches westward to the Mississippi River. The southern boundary of 36° 30′ has been adopted (instead of Mason and Dixon's line) because it coincides better than any other direct geographical line with the natural division between the cooler-temperate and the warm-temperate vegetation,—between the flora of the northern and of the southern Atlantic states. Few characteristically southern plants advance to the north of it, and those chiefly on the coast of the low south-eastern corner of Virginia, in the Dismal Swamp, and the environs of Norfolk. Could we vary the line where it intersects the longitude of Washington, carrying it north until it reaches James River, and thence due east again, the small quadrangle thus excluded would exclude nearly all the properly southern indige-

* Manual of the Botany of the Northern United States; second edition; including Virginia, Kentucky, and all east of the Mississippi: arranged according to the Natural System; by ASA GRAY, (the Mosses and Liverworts by Wm. S. Sullivant). With 14 plates, illustrating the Genera of the Cryptogamia. New York: George P. Putnam & Co., 1856.

nous plants now comprised in the volume,* and mark the true division eastward between our southern and our northern botanical regions, namely, at the northern limit of the Live Oak, the Long-leaved Pine, and the Black Moss (*Tillandsia usneoides*), which grows pendent from their boughs.

On the Mississippi, the plant most southern in character which crosses the parallel is *Jussiæa repens*. This sparingly extends up the Ohio to lat. 38°, where also the *Taxodium* reaches about as far north as on the Atlantic coast.

In the elevated region through which the middle of our southern boundary passes, great numbers of northern plants are of course found to extend much farther southward.

Our western boundary, the Mississippi River, while it takes in a considerable prairie-region, excludes nearly all the plants peculiar to the wide western woodless plains, which stretch from the Saskatchewan to Texas and New Mexico, and approach our borders in Minnesota and Iowa. A list of the plants which we may be said to have derived from this region will be given hereafter.

The northern boundary, being that between the United States and British America, varies through about five degrees of latitude, and nearly embraces Canada proper on the east and on the

* It would apparently exclude from the flora of the Northern States the following species:—

Gordonia Lasianthus.
Stuartia Virginica.
Zanthoxylum Carolinianum.
Berchemia volubilis.
Viburnum obovatum.
Mitreola petiolata.
Liatris odoratissima.
" paniculata.
Sericocarpus tortifolius.
Chrysopsis gossypina.
Baccharis glomeruliflora.
Kalmia hirsuta.
Ilex Cassine.
" myrtifolia.
" Dahoon.
Gelsemium sempervirens.
Forsteronia difformis.
Olea Americana.
Fraxinus platycarpa.
Benzoin melissæfolium.
Tetranthera geniculata.
Stillingia sylvatica.
Quercus virens.
" cinerea.
Sagittaria falcata.
Burmannia biflora.
Tillandsia usneoides.
Smilax Walteri.
" lanceolata.
Zygadenus glaberrimus.
Mayaca Michauxii.
Pæpalanthus flavidus.
Lachnocaulon Michauxii.
Vilfa Virginica.
Ctenium Americanum.
Uniola paniculata.
Paspalum distichum.
" Digitaria.

Probably a good many more southern species inhabit this corner of Virginia, of which I have as yet no indications. There is little doubt that the long-leaved Pine crosses the line, and perhaps an arborescent *Yucca* grows on the sea-shore.—Of characteristically southern trees that have found their way still farther northward on the coast, even beyond Virginia, I can only mention two, namely, the Red Bay (*Persea Carolinensis*) and the Bald Cypress (*Taxodium distichum*), both found in Delaware, a little beyond lat. 38° 30′. Two other characteristic trees, viz., the Palmetto and *Magnolia grandiflora*, stop about as far short of our line as the two former pass beyond it.

west; so that the volume in question probably contains nearly all the plants of Canada East, south of the St. Lawrence and of lat. 47°, and of Canada West, south of lat. 46°, or perhaps 45°. Our northern boundary rises highest at its western extremity, even to lat. 49°. But the botany of the district beyond Fond du Lac, lat. 47°, is little known. Probably many plants of the northwestern plains are to be found there, which are otherwise strangers to our region, as well as all or most of the species known to occur on the northern but not on the southern shore of Lake Superior.*

A list of the additional Canadian species, as far as now known, is appended.†

The simplicity of our flora, as a purely northern temperate one, is preserved by the absence throughout our limits of high mountains and of any considerable extent of elevated land, es-

* The following Phænogamous plants, contained in Prof. Agassiz's published list of the plants gathered on the north shore of Lake Superior, in his expedition made in 1848, are not included in the Botany of the Northern States, viz :

Ribes oxyacanthoides.
Lonicera involucrata.
Corispermum hyssopifolium.
Tofieldia calyculata vel palustris.
Carex Vahlii.

To which I may add, that obscure and ambiguous Grass, the *Aira melicoides*, Michx., (Graphephorum, *Beauv.*). The last two, viz., *Tofieldia palustris* and *Carex Vahlii*, with an interesting Fern, *Allosorus acrostichoides*, are in Prof. Whitney's list (in Messrs. Foster and Whitney's Report on the Geology of the Lake Superior Land District, 1851), and having been gathered on Isle Royale, strictly claim admission into our Flora. But I was not aware in time that Isle Royale fell within the limits of the United States; and, seeing that in any case it geographically and botanically pertains to the northern shore, where the vegetation begins to display a subalpine character, which it does not upon the south side, I determined to take the southern shore of the lake for our boundary.

† This list includes the few just enumerated as found on the immediate coast of Lake Superior, although only one of the seven, viz., Ribes oxyacanthoides, is truly Canadian. Three of them come from the northwest and west, and three from the Hudson's Bay country. I exclude the introduced species, reckoning among these *Hesperis matronalis*, *Sisymbryum Sophia*, &c.: also all those mentioned as Canadian by Pursh, which have not been confirmed by later observers.

Aquilegia vulgaris (A. brevistyla, *Hook.*).
Turritis patula.
" retrofractra.
Thlaspi alpestre (?)
Linum perenne.
Oxytropis Lamberti (?)—the plant of Quebec, so-called.
Ribes oxyacanthoides.
Lonicera involucrata.
Hieracium vulgatum.
Nardosmia frigida.
Matricaria inodora.
Aster Cornuti.
Gentiana acuta.
Polemonium cæruleum.
Corispermum hyssopifolium.
Elæaguus argentea.
Tofieldia palustris.
Goodyera (Spiranthes, *Hook.*) decipiens.
Carex Vahlii.
Graphephorum melicoides. (Poæ sp.?)
Elymus Europæus, *ex Hook.*
Allosorus acrostichoides.

So far as we know at present, therefore, only 22 indigenous Phænogamous species and Ferns (of which 12 are also European) would therefore be added, by comprising Canada proper, that is, the country bordering the north of the St. Lawrence and of the Great Lakes.

pecially at the north, and the consequent paucity of truly alpine or even subalpine species. We have an alpine region indeed; but it is restricted to a few isolated mountain-tops in the northern part of New England and New York, between or near lat. 44° and 45°. The White Mountains of New Hampshire furnish far the larger part, viz., the range strictly so called, with six or seven square miles (taken horizontally) of alpine region, of which the highest point slightly exceeds 6200 feet in elevation, and its lower limit is about 4500 feet above the level of the sea, and Mount Lafayette (reaching to 5200 feet) along with other smaller patches, together making up almost as much more. Mount Katahdin in Maine (about 5300 feet high) may furnish a square mile or so of alpine region. The Green Mountains of Vermont (with a maximum elevation of 4360 feet) present mere vestiges of alpine vegetation in one or two places; and two or three summits of the Adirondack Mountains of northeastern New York (with a maximum elevation said to exceed 5400) are of a more decidedly alpine character, but apparently of small extent and far from rich in species.

The southern shore of Lake Superior affords no alpine and perhaps no strictly subalpine species; nor do any occur in the Alleghany Mountains, although they rise to above 5000 feet at one point in the south of Virginia,* and to 6000 and about 6300 in North Carolina. *Scirpus cæspitosus*, *Lycopodium selago*, *Andræa petrophila*, and *Cetraria Islandica*, are the most nearly alpine species known in the Alleghany Mountains. As will be seen by the list on a following page, the number of our truly alpine species does not equal that of the southern plants which have extended into the low southeastern corner of Virginia.

After that of Europe, no northern temperate flora of equal extent, and perhaps no flora of any large region, is so well known as that of the Northern United States, at least as to its Phanerogamia and highest Cryptogamia: and although very much still remains to be done, yet we are now in condition profitably to compare our vegetation with that of Europe, and also, though less critically, with that of other parts of the northern temperate zone.

The following tables exhibit the principal elements of our flora, and some of its relations to the European, &c.

* The White Top Mountain in Virginia, just within its southern boundary, is commonly said to be about 6000 feet in elevation; but this is probably an exaggeration.

List of the Natural Orders of the Flora of the Northern United States, with the number of Genera and Species comprised in them,—distinguishing the introduced and the indigenous Species,—and of the indigenous Species common to this district and to Europe.

CLASS I. DICOTYLEDONÆ S. EXOGENÆ.

Orders.	Whole No. of Genera.	No. of Genera with Indigenous Species.	No. of Introduced (naturalized and adventive) Species.	Whole No. of Species.	No. of Indigenous Species.	No. of our Indigenous Species common to Europe.
SUBCLASS. I. ANGIOSPERMÆ.						
Ranunculaceæ,	21	20	6	55	49	10
Magnoliaceæ,	2	2		6	6	
Anonaceæ,	1	1		1	1	
Menispermaceæ,	3	3		3	3	
Berberidaceæ,	5	5	1	6	5	
Nelumbiaceæ,	1	1		1	1	
Cabombaceæ,	1	1		1	1	
Nymphæaceæ,	2	2		3	3	1
Sarraceniaceæ,	1	1		2	2	
Papaveraceæ,	6	2	5	7	2	
Fumariaceæ,	4	3	1	7	6	
Cruciferæ,	20	16	14	60	46	11
Capparidaceæ,	1	1		1	1	
Resedaceæ,	1		1	1		
Violaceæ,	2	2	1	19	18	1
Cistaceæ,	3	3		7	7	
Droseraceæ,	1	1		4	4	2
Parnassiaceæ,	1	1		3	3	1
Hypericaceæ,	3	3	1	19	18	
Elatinaceæ,	1	1		1	1	
Caryophyllaceæ,	19	11	17	47	30	13
Portulacaceæ,	4	3	1	5	4	
Malvaceæ,	9	7	6	15	9	
Tiliaceæ,	1	1		2	2	
Camelliaceæ,	2	2		2	2	
Linaceæ,	1	1		2	2	
Oxalidaceæ,	1	1		3	3	2
Geraniaceæ,	2	1	2	5	3	1
Balsaminaceæ,	1	1		2	2	
Limnanthaceæ,	1	1		1	1	
Rutaceæ,	2	2		3	3	
Anacardiaceæ,	1	1		6	6	
Vitaceæ,	2	2		7	7	
Rhamnaceæ,	4	4	1	7	6	
Celastraceæ,	2	2		3	3	
Sapindaceæ,	4	4	1	11	10	
Polygalaceæ,	1	1		13	13	
Leguminosæ,	36	33	14	105	91	4
Rosaceæ,	18	17	5	76	71	16

CLASS I—*continued.*

Orders.	Whole No. of Genera.	No. of Genera with Indigenous Species.	No. of Introduced (naturalized and adventive) Species.	Whole No of Species.	No. of Indigenous Species.	No. of our Indigenous Species common to Europe.
Calycanthaceæ,	1	1		3	3	
Melastomaceæ,	1	1		3	3	
Lythraceæ,	4	4	1	8	7	1
Onagraceæ,	9	9		36	36	10
Loasaceæ,	1	1		1	1	
Cactaceæ,	1	1		1	1	
Grossulaceæ,	1	1		7	7	1
Passifloraceæ,	1	1		2	2	
Cucurbitaceæ,	3	3		3	3	
Crassulaceæ,	3	3	1	6	5	
Saxifragaceæ,	11	11		22	22	5
Hamamelaceæ,	3	3		3	3	
Umbelliferæ,	26	21	5	42	37	2
Araliaceæ,	1	1		6	6	
Cornaceæ,	2	2		11	11	
Caprifoliaceæ,	7	7		27	27	3
Rubiaceæ,	9	9	1	24	23	4
Valerianaceæ,	2	2	1	8	7	
Dipsaceæ,	1		1	1		
Compositæ,	83	67	27	300	273	9
Lobeliaceæ,	1	1		12	12	1
Campanulaceæ,	2	2		5	5	1
Ericaceæ,	27	27		62	62	19
Galacineæ,	1	1		1	1	
Aquifoliaceæ,	2	2		10	10	
Styracaceæ,	3	3		5	5	
Ebenaceæ,	1	1		1	1	
Sapotaceæ,	1	1		2	2	
Plantaginaceæ,	1	1	2	8	6	1
Plumbaginaceæ,	1	1		1	1	1
Primulaceæ,	11	10	1	17	16	6
Lentibulaceæ,	2	2		12	12	4
Bignoniaceæ,	4	2	2	4	2	
Orobanchaceæ,	4	4		5	5	
Scrophulariaceæ,	26	24	11	65	54	10
Acanthaceæ,	2	2		3	3	
Verbenaceæ,	4	2	3	10	7	
Labiatæ,	33	21	22	71	49	4
Borraginaceæ,	11	5	9	25	16	3
Hydrophyllaceæ,	4	4		11	11	
Polemoniaceæ,	4	4		12	12	1
Convolvulaceæ,	7	5	5	20	15	1
Solanaceæ,	6	2	6	10	4	
Gentianaceæ,	9	8	3	27	24	2
Apocynaceæ,	3	3		4	4	
Asclepiadaceæ,	5	4	1	22	21	

CLASS II—*continued.*

Orders.	Whole No. of Genera.	No. of Genera with Indigenous Species.	No. of Introduced (naturalized and adventive) Species.	Whole No of Species	No. of Indigenous Species.	No of our Indigenous Species common to Europe.
Oleaceæ,	5	4	1	10	9	
Aristolochiaceæ,	2	2		6	6	
Nyctaginaceæ,	1	1		1	1	
Phytolaccaceæ,	1	1		1	1	
Chenopodiaceæ,	9	7	11	21	10	6
Amarantaceæ,	6	5	9	14	5	
Polygonaceæ,	4	3	10	32	22	6
Lauraceæ,	4	4		5	5	
Thymeleaceæ,	1	1		1	1	
Elæagnaceæ,	1	1		1	1	
Santalaceæ,	2	2		3	3	
Loranthaceæ,	1	1		1	1	
Saururaceæ,	1	1		1	1	
Ceratophyllaceæ,	1	1		1	1	1
Callitrichaceæ,	1	1		3	3	3
Podostemaceæ,	1	1		1	1	
Euphorbiaceæ,	9	9	5	33	28	
Empetraceæ,	2	2		2	2	1
Urticaceæ,	11	10	4	19	15	1
Platanaceæ,	1	1		1	1	
Juglandaceæ,	2	2		9	9	
Cupuliferæ,	6	6		25	25	1
Myricaceæ,	2	2		3	3	1
Betulaceæ,	2	2		10	10	4
Salicaceæ,	2	2	4	28	24	3
Subcl. II. GYMNOSPERMÆ.						
Coniferæ,	8	8		20	20	2
Total,	622	522	223	1713	1490	180

CLASS II. MONOCOTYLEDONEÆ seu ENDOGENÆ.

Araceæ,	6	6		7	7	2
Typhaceæ,	2	2		7	7	6
Lemnaceæ,	1	1		5	5	4
Naiadaceæ,	5	5		16	16	12
Alismaceæ,	5	5		12	12	4
Hydrocharidaceæ,	3	3		3	3	2
Burmanniaceæ,	1	1		1	1	
Orchidaceæ,	17	17		51	51	10
Amaryllidaceæ,	4	4		4	4	
Hæmodoraceæ,	3	3		4	4	
Bromeliaceæ,	1	1		1	1	
Iridaceæ,	2	2		6	6	
Dioscoreaceæ,	1	1		1	1	
Smilaceæ,	3	3		18	18	

CLASS I—*continued.*

Orders.	Whole No. of Genera.	No. of Genera with Indigenous Species.	No of Introduced (naturalized and adventive) Species.	Whole No. of Species.	No. of Indigenous Species.	No. of our Indigenous Species common to Europe.
Liliaceæ,	12	9	4	28	24	5
Melanthaceæ,	12	12		21	21	1
Juncaceæ,	3	3		26	26	14
Pontederiaceæ,	3	3		4	4	
Commelynaceæ,	2	2		6	6	
Xyridaceæ,	2	2		4	4	
Eriocaulonaceæ,	3	3		5	5	1
Cyperaceæ,	16	16	1	214	213	48
Gramineæ,	65	55	32	194	162	32
	172	159	37	638	601	141
Total Phænogamous Plants.	794	681	260	2351	2091	321
CLASS III. ACROGENÆ.						
Equisetaceæ,	1	1		10	10	8
Filices,	20	20		49	49	20
Lycopodiaceæ,	2	2		12	12	6
Hydropterides (Marsileaceæ),	2	2		4	4	1
	25	25	0	75	75	35
CLASS IV. ANOPHYTA.						
Musci,	80	80	0	394	394	255
Hepaticæ,	38	38	0	108	108	65
Total,	118	118	0	502	502	320
Total Cryptogamia, Cl. 3 and 4,	143	143	0	577	577	355
Total of the 4 Classes,	937	824	260	2928	2668	676

It is plain enough that the numbers in this tabular view must be essentially influenced throughout by one's views as to the limitation of species and genera. In the hands of a few botanists, the flora of the Northern States might exhibit a somewhat smaller number of species than it here does; but with most, there would undoubtedly be a stronger tendency in the opposite direction. As it is obviously impossible at present to reduce the various ideas and shades of difference that prevail respecting species to one common standard, all that can be done is to indicate the bias, or what astronomers call the *personal equation*, of each author, which must be duly considered when different

floras are to be compared. This is not the place to discuss the principles involved in the general question, nor to explain or defend any conclusions to which I may have arrived;—except to say that my determination of species in each particular case has been based on the evidence before me as irrespective of all theoretical considerations as possibly could be. It is necessary to state, however, that, so far as I can judge, the authors of the principal and most esteemed recent European Floras, if in my place, would be likely to increase the present number of our Phænogamous plants and Ferns about five per cent. One school, indeed, would doubtless add at least ten or twelve per cent. to the species here received, and give results quite incommeasurable with my own. I can only say, on my own part, that an enlarged experience certainly inclines one to take broader views of species than those which prevail among the generality of European botanists.

The numerical comparison of our Phænogamous with our Cryptogamous species, however interesting it might become in a complete flora, is here of little moment; only the higher Cryptogamia being included. Moreover, it should be noted that the *Musci* and *Hepaticæ* enumerated in the above table are those of a geographical area about twice that of the higher or Acrogenous Cryptogamia and the Phænogamia. For the distinguished American muscologist who elaborated these two orders for our 'Botany of the Northern States,' anxious to afford facilities for the study of our mosses throughout the country, has included all known to him within the whole United States east of the Mississippi, and even some as yet found only to the north and west of these limits. It is evident, also, that the number of forms admitted as species is proportionally larger in these two orders than in the rest of the work. On the other hand it is to be considered how little our mosses have as yet been collected and studied, and how likely it is, in view of their general wide range, that most of these outlying species may yet be detected within the Northern States, including Virginia and Kentucky.

We naturally restrict our attention mainly to the Phænogamous vegetation, as best known in all countries and affording the most precise data for comparison. And we exclude at once the 260 *introduced* species, most if not all of which have become denizens of our country since its settlement by Europeans, and in consequence of that settlement;—leaving the question of their origin, introduction, &c., for future consideration. Their admission into the account in the comparing our flora with that of Europe, as has been done, seriously vitiates our conclusions.*

* Thus Mr. Watson, as cited by Alph. DeCandolle (Geogr. Bot. p. 511) enumerates 602, out of 1428 phænogamous British plants, as common to Great Britain and America. I count only 321 out of 2091 phænogamous species *indigenous* to the Northern United States as indigenous also to Europe.

The numerical elements of our Phænogamous flora, considered as to classes, are, as the tabular view shows:

Dicotyledoneæ or Exogenæ,	1490 species in	522 genera.
Monocotyledoneæ or Endogenæ,	601 "	159 "
Total Phænogamous indigenous plants,	2091 "	681 "

Or about 2½ Dicotyledonous to one Monocotyledonous species.

Their distribution among the 132 Natural Orders represented in our flora (*Resedaceæ* and *Dipsaceæ* of the above table being excluded, as having no indigenous representatives), is shown in the following:

List of the principal Phænogamous Natural Orders represented in the flora of Northern United States, arranged according to the number of indigenous species they severally comprise.

	Species.		Species.
Compositæ,	273	Liliaceæ,	24
about ⅛th of the 2091 Phanerogamia.		Rubiaceæ,	23
Cyperaceæ, about $\frac{1}{10}$th, "	213	Saxifragaceæ,	22
Gramineæ, about $\frac{1}{13}$th, "	162	Polygonaceæ,	22
Leguminosæ, about $\frac{1}{24}$th, "	91	Asclepiadaceæ,	21
Rosaceæ, about $\frac{1}{29}$th, "	71	Melanthaceæ,	21
Ericaceæ,	62	Coniferæ,	20
Scrophulariaceæ,	54	Violaceæ, Hypericaceæ, and	
Orchidaceæ,	51	Smilaceæ, each	18
Ranunculaceæ,	49	Primulaceæ, Borraginaceæ,	
Labiatæ,	49	and Naidaceæ, each	16
Cruciferæ,	46	Convolvulaceæ and Urticaceæ,	
Umbelliferæ,	37	each,	15
Onagraceæ,	36	Polygalaceæ,	13
Caryophyllaceæ,	30	Lobeliaceæ, Lentibulaceæ, Pole-	
Euphorbiaceæ,	28	moniaceæ, and Alismaceæ, each,	12
Caprifoliaceæ,	27	Cornaceæ, and Hydrophyllaceæ,	
Juncaceæ,	26	each,	11
Cupuliferæ,	25	Sapindaceæ, Aquifoliaceæ, Che-	
Salicaceæ,	24	nopodiaceæ, and Betulaceæ,	
Gentianaceæ,	24	each,	10

Only 46 of our orders have 10 or more indigenous species: 63 orders have from 2 to 9 species, and 23 orders are represented each by a single species. The average allows 15·09 species to an order.

Alphonse De Candolle and others have remarked that in almost every flora of the temperate zone which is pretty thoroughly known, the eight or nine largest families comprise half of its Phænogamous plants. In the present case the first nine families, having 1026 species, lack nineteen of making half; the sum of ten families exceeds the moiety by thirty. The result is nearly the same as that brought out by De Candolle from a similar schedule, tabulated by him from Beck's Botany of the Northern

and Middle States, north of Virginia, 1833, although the elements are considerably different and the ten largest orders are not the same throughout.*

Moreover, our ten predominant families do not properly correspond with the ten mentioned by De Candolle as generally predominant in the temperate regions of the northern hemisphere: viz. "of the first rank, *Compositæ*, *Gramineæ*, *Cyperaceæ*, *Leguminosæ;* then the *Cruciferæ*, *Umbelliferæ*, and *Caryophyllaceæ*, and then, though less decidedly, the *Labiatæ*, *Rosaceæ*, and *Scrophulariaceæ*.† Nor would they do so if, by dividing the Ericaceæ into smaller orders, we were to exclude that family from the list of those (eleven in number) which severally comprise not less than two per cent of our phænogamous species. The three most predominant families accord indeed with De Candolle's conclusion, only the *Cyperaceæ* with us are remarkable for surpassing the *Gramineæ*. But the next three in our list are quite different, even if we omit *Ericaceæ*, being *Rosaceæ*, *Scrophulariaceæ*, and *Orchidaceæ;* and all three of De Candolles second rank fall below our first ten; and one of them, the order *Caryophyllaceæ* would fall still lower, if it were not reinforced by the *Illecebreæ*, so generally regarded as a distinct family.

It is easy to see that these differences are owing to the unusual richness of our flora in *Cyperaceæ* (chiefly in *Carices*), and to our poverty in *Cruciferæ*, *Umbelliferæ*, *Caryophyllaceæ*, and *Labiatæ*, especially in the second and fourth, at least as compared with corresponding parts of Europe.

* The schedule drawn from Beck's Botany is as follows:

Compositæ,	265	
Gramineæ,	169	
Cyperaceæ,	157	
Rosaceæ,	97	
Amentaceæ,	94	=1066 species out of 2125 Phænogamous plants.
Leguminosæ,	80	
Labiatæ,	59	
Ranunculaceæ,	50	
Scrophulariaceæ,	48	
Orchidaceæ,	47	

The differences are readily to be accounted for. 1. The substitution of *Amentaceæ* in this list for *Ericaceæ* in the other, results from the former Jussiæan order having been preserved entire by Beck, but distributed into several in the present work; while I have admitted the order *Ericaceæ* in its most extensive sense. 2. The precedence of *Cyperaceæ* to *Gramineæ* in my list,—which appears not to be the case in corresponding floras of the Old World,—is wholly owing to the great increase in the number of *Carices*, in which the Northern United States are absolutely very rich; which increase has resulted from the remarkable attention and repeated elaboration this genus has received since Dr. Beck's time, from several hands, and perhaps also from a minuter discrimination of the species than in other families. 3. The order *Rosaceæ*, which strangely takes precedence of the *Leguminosæ*, is unduly expanded by a crowd of nominal or traditional species, and has four times as many introduced species as the latter family. 4. The naturalized plants being included, alters the proper proportion of most of these orders, and swells the number of the Phænogamous plants to 2125, while we count only 2091 truly indigenous species within an area about one-half larger and now much more thoroughly known.

† Alph. De Candolle: Geogr. Bot., p. 1245.

I must not stop here to compare our flora with that of Europe as respects the proportions of the *predominant* families. The data on our part for such comparison are recorded above. I pass on to notice some *characteristic* features which depend upon positive differences in the families.

The orders represented in the N. European flora and not in ours are the *Resedaceæ*, *Frankeniaceæ*, *Tamariscineæ*, *Zygophyllaceæ*, *Dipsaceæ*, *Globulariaceæ*, and *Butomaceæ*;—all very small orders; five of the seven are not represented at all by indigenous species in North America; two of them are represented on our continent in what answers to the Mediterranean region.

Of our 132 orders none is peculiar to our district, and only two are restricted to the United States; namely, *Limnanthaceæ*, of one species in the Northern States and one or two in California, and *Galacineæ*, of one genus and species,—a *genus incertæ sedis*, rather than an order.

Our orders peculiar to America are the following:—

Sarraceniaceæ,	Cactaceæ,	Hydrophyllaceæ,
Limnanthaceæ,	Galacineæ,	Bromeliaceæ;
Loasaceæ,		

all of which, except *Galacineæ* and perhaps *Bromeliaceæ*, are also represented on the western side of our continent. Besides these the following 19 orders are extra-European. Those which have known representatives in western North America, that is, in Oregon and California, are repeated in the second column; those known in corresponding parts of eastern Asia, i. e. in Japan, China, and the Himalayas, in the third column.

Extra-European Orders not peculiar to America.

Extra-European Orders of the Flora of the Northern States.	Also represented in Western N. America.	Represented in Japan, China, or Himalayas.
Magnoliaceæ.		Magnoliaceæ.
Anonaceæ.		Anonaceæ.
Menispermaceæ.		Menispermaceæ.
Nelumbiaceæ.		Nelumbiaceæ.
Cabombaceæ.		Cabombaceæ.
Calycanthaceæ.		Calycanthaceæ.
Melastomaceæ.		Melastomaceæ.
Passifloraceæ.		Passifloraceæ.
Hamamelacæ.		Hamamelaceæ.
Sapotaceæ.		Sapotaceæ.
Bignoniaceæ.	Bignoniaceæ (Martynia) ?	Bignoniaceæ.
Nyctaginaceæ.	Nyctaginaceæ.	Nyctaginaceæ ?
Phytolaccaceæ.	Phytolaccaceæ.	Phytolaccaceæ.
Saururaceæ.	Saururaceæ.	Saururaceæ.
Podostemaceæ.		Podostemaceæ.
Burmanniaceæ.		Burmanniaceæ.
Hœmodoraceæ.		
Commelynaceæ.		Commelynaceæ.
Xyridaceæ.		Xyridaceæ.

Thus it appears, 1, that, of our 19 extra-European orders not peculiarly American, only 3 or 4 are represented on the western or Pacific side of the United States, while all but one are represented in the corresponding parts of Eastern Asia;—indicating a curious analogy in the vegetation of the eastern sides of the two great continental masses in the northern hemisphere, which is also borne out, though not so strikingly, in a comparison of the genera.

2. That the flora of the Northern United States is remarkably rich in ordinal types, as compared with Europe, which, (exclusive of the Mediterranean region, furnished with two or three), has only seven orders that we have not, while we have 26 that are wholly unknown to the European flora.

3. And it is worth noticing that our additional or characteristic orders are all of warm-temperature or sub-tropical general character (which is the more remarkable when the lower mean temperature of the year as compared with that of Western Europe is considered): all of these 26 orders have their principal development in the tropical regions, excepting six of the smaller ones; and three of these have tropical or sub-tropical representatives.

4. But the peculiar and extra-European families do not predominate, nor overcome the general European aspect of our vegetation, on account of the fewness of their species. Of the largest in our flora (*Hydrophyllaceæ*) we count only 11 species; and the whole 26 orders give us only 64, or barely three per cent of our phænogamous species.

Our Phænogamous genera, 681 in number, average three species apiece. Far the largest genus is *Carex*, with 132 species. On the other hand one half of our genera are represented by single species; and about 92 of these are *monotypic*, having only a single known species.

The genera which are strictly confined within the geographical limits of this work are only three, namely, *Napæa*, *Sullivantia*, and *Hemianthus* (the last a dubious genus); and all three are monotypic.

The number of our genera which have no indigenous representatives in Europe appears to be 353, or twelve more than half of our whole number, (the naturalized plants being of course excluded), belonging to 95 families. In the following table (which is hastily prepared, and likely to contain not a few errors), our extra-European Phænogamous genera are enumerated, under their respective families, and their distribution in longitude is attempted to be given in the two parallel columns.

Phænogamous Genera of the Flora of the Northern United States not common to Europe, with indications of their distribution westward, and in Eastern Temperate Asia.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e., in Oregon and California.	Occurring in E. Asia, i. e., in Japan, China, or Himalayas.
Ranunculaceæ.	Trautvetteria.	Trautvetteria.	Trautvetteria.
	Zanthorhiza.		
	Hydrastis.		
	Cimicifuga.	Cimicifuga.	Cimicifuga.
Magnoliaceæ.	Magnolia.		Magnolia.
	Liriodendron.		
Anonaceæ.	Asimina.		
Menispermaceæ.	Menispermum.		
	Cocculus.		Cocculus.
	Calycocarpum.		
Berberidaceæ.	Caulophyllum.		
	Diphylleia.		
	Jeffersonia.		
	Podophyllum.		Podophyllum.
Nelumbiaceæ.	Nelumbium.		Nelumbium.
Cabombaceæ.	Brasenia.		Brasenia.
Sarraceniaceæ.	Sarracenia.		
Papaveraceæ.	Stylophorum.		Stylophorum.
	Sanguinaria.		
Fumariaceæ.	Adlumia.		
	Dicentra.	Dicentra.	Dicentra.
Cruciferæ.	Iodanthus.		
	Leavenworthia.		
Capparidaceæ.	Polanisia.		Polanisia.
Violaceæ.	Solea.		
Cistaceæ.	Hudsonia.		
	Lechea.		
Hypericaceæ.	Ascyrum.		
	Elodea.		
Caryophyllaceæ.	Anychia.		
	Mollugo.	Mollugo.	Mollugo.
Portulaccaceæ.	Sesuvium.	Sesuvium.	
	Talinum.	Talinum.	
	Claytonia.	Claytonia.	
Malvaceæ.	Callirrhöe.		
	Napæa.		
	Sida.	Sida.	Sida.
	Kosteletzkya.	Kosteletzkya.	
Camelliaceæ.	Gordonia.		Gordonia.
	Stuartia.		Stuartia.
Limnanthaceæ.	Floerkea.		
Rutaceæ.	Zanthoxylum.		Zanthoxylum.
	Ptelea.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas.
Vitaceæ.	Ampelopsis.		Ampelopsis?
Rhamnaceæ.	Berchemia.		Berchemia.
	Ceanothus.	Ceanothus.	
Sapindaceæ.	Æsculus.	Æsculus.	Æsculus.
	Negundo.	Negundo.	Negundo.
Leguminosæ.	Crotalaria.		Crotalaria.
	Dalea.	Dalea.	
	Petalostemon.	Petalostemon.	
	Amorpha.	Amorpha.	
	Robinia.		
	Wistaria.		Wistaria.
	Tephrosia.		Tephrosia.
	Æschynomene.		Æschynomene.
	Desmodium.		Desmodium.
	Lespedeza.		Lespedeza.
	Stylosanthes.		
	Apios.		
	Rhynchosia.		Rhynchosia.
	Galactia.		
	Amphicarpæa.		
	Clitoria.		Clitoria.
	Centrosema.		
	Baptisia.		
	Cladrastis.		
	Cassia.		Cassia.
	Gymnocladus.		
	Gleditschia.		Gleditschia.
	Desmanthus.	Desmanthus.	Desmanthus.
	Schrankia.		
Rosaceæ.	Gillenia.		
	Dalibarda.		
Calycanthaceæ.	Calycanthus.	Calycanthus.	
Melastomaceæ.	Rhexia.		
Lythraceæ.	Ammannia.	Ammannia.	Ammannia.
	Nesæa.		
	Cuphea.		
Onagraceæ.	Œnothera.	Œnothera.	
	Gaura.	Gaura.	
	Jussiæa.		Jussiæa.
	Proserpinaca.		
Loasaceæ.	Mentzelia.	Mentzelia.	
Cactaceæ.	Opuntia.	Opuntia.	
Cucurbitaceæ.	Sicyos.	Sicyos.	Sicyos.
	Echinocystis.		
	Melothria.		
Crassulaceæ.	Penthorum.		Penthorum.
Saxifragaceæ.	Astilbe.		Astilbe.

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas.
	Boykinia.	Boykinia.	
	Sullivantia.		
	Heuchera.	Heuchera.	
	Mitella.	Mitella.	Mitella.
	Tiarella.	Tiarella.	Tiarella.
	Itea.		
	Hydrangea.		Hydrangea.
	Philadelphus.	Philadelphus.	Philadelphus.
Hamamelaceæ.	Hamamelis.		Hamamelis.
	Fothergilla.		
	Liquidambar.		Liquidambar.
Umbelliferæ.	Crantzia.		
	Polytænia.		
	Archemora.		Archemora.
	Tiedemannia.		
	Thaspium.	Thaspium.	
	Zizia.		
	Discopleura.		
	Cryptotænia.		Cryptotænia.
	Osmorhiza.	Osmorhiza.	Osmorhiza.
	Eulophus.		
	Erigenia.		
Cornaceæ.	Nyssa.		
Caprifoliaceæ.	Symphoricarpus.	Symphoricarpus.	
	Diervilla.		Diervilla(Weigela).
	Triosteum.		
Rubiaceæ.	Spermacoce.		
	Diodia.		
	Cephalanthus.	Cephalanthus.	
	Mitchella.		Mitchella.
	Oldenlandia.		Oldenlandia.
	Mitreola.		Mitreola.
	Spigelia.		
	Polypremum.		
Compositæ.	Vernonia.		Vernonia.
	Elephantopus.		Elephantopus.
	Sclerolepis.		
	Liatris.		
	Kuhnia.		
	Mikania.		
	Conoclinium.		
	Adenocaulon.	Adenocaulon.	
	Sericocarpus.	Sericocarpus.	
	Diplopappus.	Diplopappus.	Diplopappus.
	Boltonia.		
	Brachychæta.		
	Bigelovia.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas.
	Chrysopsis.	Chrysopsis.	
	Pluchea.		Pluchea.
	Baccharis.	Baccharis.	
	Polymnia.		
	Chrysogonum.		
	Silphium.		
	Parthenium.		
	Iva.		
	Tetragonotheca.		
	Eclipta.		Eclipta.
	Borrichia.		
	Heliopsis.		
	Echinacea.		
	Rudbeckia.	Rudbeckia.	
	Lepachys.		
	Helianthus.	Helianthus.	
	Actinomeris.		
	Coreopsis.	Coreopsis.	
	Verbesina.		
	Dysodia.		
	Hymenopappus.	Hymenopappus.	
	Helenium.	Helenium.	
	Leptopoda.		
	Baldwinia.		
	Marshallia.		
	Erechthites.		
	Cacalia.		Cacalia.
	Krigia.		
	Cynthia.		
	Nabalus.		
	Troximon.	Troximon.	
	Pyrrhopappus.		
Ericaceæ.	Gaylussacia.		
	Chiogenes.		
	Epigæa.		
	Gaultheria.	Gaultheria.	
	Leucothoë.		
	Oxydendrum.		
	Clethra.		Clethra.
	Kalmia.	Kalmia.	
	Menziesia.	Menziesia.	
	Rhodora.		
	Leiophyllum.		
	Pterospora.	Pterospora.	
	Schweinitzia.		
Galacineæ.	Galax.		
Aquifoliaceæ.	Nemopanthes.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon or California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas.
Styracaceæ.	Halesia.		
	Symplocos.		Symplocos.
Sapotaceæ.	Bumelia.		
Primulaceæ.	Dodecatheon.	Dodecatheon.	
Bignoniaceæ.	Tecoma (also Catalpa.)		Tecoma (also Catalpa.)
	Bignonia.		
Orobanchaceæ.	Epiphegus.		
	Conopholis.		
	Aphyllon.	Aphyllon.	
Scrophulariaceæ.	Collinsia.	Collinsia.	
	Chelone.	Chelone.	
	Pentstemon.	Pentstemon.	
	Mimulus.	Mimulus.	
	Conobea.		
	Herpestis.	Herpestis.	Herpestis.
	Ilysanthes.		Ilysanthes.
	Hemianthus.		
	Synthyris.	Synthyris.	
	Buchnera.		Buchnera.
	Seymeria.		
	Gerardia.		
	Schwalbea.		
	Gelsemium.		Gelsemium.
Acanthaceæ.	Dianthera.		
	Dipteracanthus.		Dipteracanthus.
Verbenaceæ.	Lippia.		
	Callicarpa.		Callicarpa.
	Phryma.		Phryma.
Labiatæ.	Trichostema.	Trichostema.	
	Isanthus.		
	Cunila.		
	Pycnanthemum.	Pycnanthemum.	
	Hedeoma.		Hedeoma.
	Collinsonia.		
	Monarda.		
	Blephilia.		
	Lophanthus.	Lophanthus.	Lophanthus.
	Cedronella.		
	Synandra.		
	Physostegia.	Physostegia.	
Borraginaceæ.	Onosmodium.		
Hydrophyllaceæ.	Hydrophyllum.	Hydrophyllum.	
	Nemophila.	Nemophila.	
	Ellisia.	Ellisia.	
	Phacelia.	Phacelia.	
Polemoniaceæ.	Phlox.	Phlox.	Phlox.

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas
	Pyxidanthera.		
Convolvulaceæ.	Stylisma.		
	Dichondra.		
Gentianaceæ.	Sabbatia.		
	Frasera.	Frasera.	
	Halenia.		Halenia.
	Bartonia.		
	Obolaria.		
Apocynaceæ.	Amsonia.		Amsonia.
	Forsteronia.		
Asclepiadaceæ.	Asclepias.	Asclepias.	
	Acerates.		
	Enslenia.		
	Gonolobus.		
Oleaceæ.	Chionanthus.		
	Forrestiera.		
Nyctaginaceæ.	Oxybaphus.	Oxybaphus.	Oxybaphus.
Phytolaccaceæ.	Phytolacca.		
Chenopodiaceæ.	Cycloloma.		
Amarantaceæ.	Montelia.		
	Acnida.		
	Iresine.		
	Frœlichia.		
Lauraceæ.	Persea.		
	Sassafras.		
	Benzoin,		Benzoin.
	Tetranthera.	Tetranthera.	Tetranthera.
Thymeleaceæ.	Dirca.		
Elæganaceæ.	Shepherdia.		
Santalaceæ.	Comandra.	Comandra.	
	Hamiltonia.		
Loranthaceæ.	Phoradendron.	Phoradendron.	
Saururaceæ.	Saururus.		Saururus.
Podostemaceæ.	Podostemon.		
Euphorbiaceæ.	Cnidoscolus.		
	Acalypha.	Acalypha.	Acalypha.
	Tragia.		
	Stillingia.		Stillingia.
	Croton.	Croton.	Croton.
	Crotonopsis.		
	Phyllanthus.		Phyllanthus.
	Pachysandra.		Pachysandra.
Urticaceæ.	Laportea.		
	Pilea.		
	Bœhmeria.		Bœhmeria.
	Planera.		
Juglandaceæ.	Carya.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas
Myricaceæ.	Comptonia.		
Coniferæ.	Taxodium.		
	Thuja.	Thuja.	Thuja.
Araceæ.	Arisæma.		Arisæma.
	Peltandra.		
	Symplocarpus.	Symplocarpus.	Symplocarpus.
	Orontium.		
Alismaceæ.	Echinodorus.		
Hydrocharidaceæ.	Limnobium.		
Burmanniaceæ.	Burmannia.		Burmannia.
Orchidaceæ.	Arethusa.		
	Pogonia.		
	Calopogon.		
	Tipularia.		
	Bletia.		
	Aplectrum.		
Amaryllidaceæ.	Pancratium.		
	Agave.		
	Hypoxys.		
Hæmodoraceæ.	Lachnanthes.		
	Lophiola.		
	Aletris.		
Bromeliaceæ.	Tillandsia.		
Iridaceæ.	Sisyrinchium.	Sisyrinchium.	
Smiliaceæ.	Trillium.	Trillium.	Trillium.
	Medeola.		
Liliaceæ.	Clintonia.	Clintonia.	Clintonia.
	Yucca.	Yucca.	
Melanthaceæ.	Uvularia.		Uvularia ?
	Prosartes.	Prosartes.	
	Melanthium.		
	Zygadenus.		Zygadenus.
	Stenanthium.		
	Amianthium.		
	Xerophyllum.	Xerophyllum.	
	Helonias.		
	Chamælirium.		
Pontederiaceæ.	Pontederia.		
	Heteranthera.		
	Schollera.		
Commelynaceæ.	Commelyna.		Commelyna.
	Tradescantia.		Tradescantia.
Xyridaceæ.	Mayaca.		
	Xyris.		Xyris.
Ericaulonaceæ.	Pæpalanthus.		
	Lachnocaulon.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas.
Cyperaceæ.	Kyllingia.		Kyllingia.
	Dulichium.		
	Hemicarpha.		
	Fuirena.		Fuirena.
	Psilocarya.		
	Dichromena.		
	Ceratoschænus.		
	Scleria.		Scleria.
Gramineæ.	Zizania.		
	Vilfa.	Vilfa.	Vilfa.
	Sporobolus.	Sporobolus.	Sporobolus.
	Muhlenbergia.	Muhlenbergia.	
	Brachyelytrum.		
	Aristida.		Aristida.
	Ctenium.		
	Bouteloua.	Bonteloua.	
	Gymnopogon.		
	Leptochloa.		Leptochloa.
	Tricuspis.		
	Diarrhena.		
	Eatonia.		
	Bryzopyrum.	Brizopyrum.	
	Uniola.		
	Arundinaria.		Arundinaria.
	Gymnostichum.		
	Amphicarpum.		
	Paspalum.		Paspalum.
	Cenchrus.	Cenchrus.	Cenchrus.
	Tripsacum.		
	Sorghum.		Sorghum.
	353	87	101

That is, 87 of our 353 extra-European phænogamous genera, or 24 per cent are common to Western North America, and 101, or 28 per cent to Eastern temperate Asia. Four per cent more of our characteristic genera are shared with an antipodal region than with the neighboring district of W. N. America. And the number is likely to increase; for we know far less of the flora of Japan and China than of California and Oregon. Drs. Hooker and Thomson's large Himalayan collections, now in the course of distribution and publication, will probably add several more to the list. Twenty-nine of these genera, or 8 per cent, are common to all three of these regions.

Our 194 genera which are neither European, N. W. American, nor E. Asiatic in temperate regions, require further discussion to show which are characteristic of Eastern North America. We will here barely notice that:

3 Belong also to Western temperate Asia, viz., *Menispermum*, *Planera*, and *Zizania*; two of these being peculiar to that district and to ours.

73 Extend southward beyond the limits of the United States and into tropical regions, or recur in the southern hemisphere.

120 Are characteristic Eastern United States genera.

As already stated, only three genera are actually restricted to the geographical area comprised in our 'Botany of the Northern United States'. If, however, we allow our area to embrace Canada, which naturally belongs to it, and also include those plants which extend southward much beyond lat. 36° 30′ only in the Alleghanies or cool upper country of the Southern States, we may enumerate 37 genera peculiar to this flora; viz.—

Zanthorhiza.	Echinocystis.	Pyxidanthera.
Hydrastis.	Sullivantia.	Dirca.
Caulophyllum.	Zizia.	Hamiltonia.
Diphylleia.	Erigenia.	Comptonia.
Jeffersonia.	Brachychæta.	Arethusa.
Adlumia.	Chiogenes.	Tipularia.
Solea.	Oxydendrum.	Aplectrum.
Hudsonia.	Rhodora.	Medeola.
Napæa.	Leiophyllum.	Helonias.
Cladrastis.	Schweinitzia.	Chamælirium.
Gymnocladus.	Galax.	Amphicarpum.
Gillenia.	Nemopanthes.	
Dalibarda.	Hemianthus.	

To show, however, how slight an influence, after all, these 37 characteristic genera exert upon our flora, we have only to remark that they comprise altogether only 39 of our species:—that is, they have only one species apiece, except *Hudsonia* and *Gillenia*, which have two each. The characteristics of our flora of the Northern States merge in those of the flora of Eastern North America, and these again into those of the North American flora generally; and no idea can be formed of the real features of a flora like ours from such a dissection, and piecemeal presentation, or from an exhibition of what is strictly peculiar to each part, rather than what is predominant,—at least as respects generic forms.

Returning now to the species,—the real exponents of vegetation;—these have already been considered as regards their numerical proportions in the several classes and orders of the flora of the Northern States: it remains to note some facts respecting their geographical distribution.

As appears from the tabular view commencing on p. 208, there are common to Europe,

180	Dicotyledonous species out of 1490,	or	12 per cent.
141	Monocotyledonous species out of 601,	or	23·4 "
321	Phænogamous Species out of 2091	or	15·3 "
35	Acrogenous Cryptogamia out of 75	or	46·6 "
320	Musci and Hepaticæ out of 502	or	63·7 "
355	Cryptogamous species out of 577	or	61·5 "

in accordance with the general fact that the lower the class the wider the geographical area occupied by the species.

In the following table I have attempted to exhibit the particular range of our indigenous phænogamous species of each natural order in longitude, through the northern temperate zone. The table has been hastily prepared, and must be often erroneous in details; but the general results are probably very near the truth.

The Indigenous Phænogamous Species of the Northern United States, viewed as to their geographical distribution around the northern temperate zone.

Natural Orders.	Whole number of species in the northern United States.	East'n N. American: not extending westward beyond the Rocky Mountains.	Extending westward to the Pacific coast or near it.	Extending into Asia.	Inhabiting Asia, but not in N. W. America.	Inhabiting Asia, but not in Europe.	Extending into Europe.	Inhabiting Europe, but not in Eastern Asia.
Class I. DICOTYLEDONEÆ, seu EXOGENÆ.								
Ranunculaceæ,	49	26	20	13	1	5	10	2
Magnoliaceæ,	6	6						
Anonaceæ,	1	1						
Menispermaceæ,	3	3						
Berberidaceæ,	5	5						
Nelumbiaceæ,	1	1						
Cabombaceæ,	1			1	1	1		
Nymphæceæ,	3	1	2	1			1	
Sarraceniaceæ,	2	2						
Papaveraceæ,	2	2						
Fumariaceæ,	6	5	1					
Cruciferæ,	46	31	13	11	2		11	
Capparidaceæ,	1	1						
Violaceæ,	18	15	3	1			1	
Cistaceæ,	7	7						
Droseraceæ,	4	2	1	1			2	1
Parnassiaceæ,	3	2	1	1			1	
Hypericaceæ,	18	18						

CLASS I.—*continued.*

Natural Orders.	Whole number of species in the north-e.n United States.	East'n N. American: not extending west-ward beyond the Rocky Mountains.	Extending westward to the Pacific coast or near it.	Extending into Asia.	Inhabiting Asia, but not in N.W. America.	Inhabiting Asia, but not in Europe.	Extending into Europe.	Inhabiting Europe, but not in Eastern Asia.
Elatinaceæ,	1	1						
Caryophyllaceæ,	30	14	15	12			13	1
Portulacaceæ,	4	4						
Malvaceæ,	9	9						
Tiliaceæ,	2	2						
Camelliaceæ,	2	2						
Linaceæ,	2	2						
Oxalidaceæ,	3	1	2	2			2	
Geraniaceæ,	3	1	1	1			1	
Balsaminaceæ,	2	2						
Limnanthaceæ,	1	1						
Rutaceæ,	3	3						
Anacardiaceæ,	6	5	1					
Vitaceæ,	7	7						
Rhamnaceæ,	6	6						
Celastraceæ,	3	2	1					
Sapindaceæ,	10	10						
Polygalaceæ,	13	13						
Leguminosæ,	91	84	7	4			4	
Rosaceæ,	71	43	23	17	3	2	16	1
Calycanthaceæ,	3	3						
Melastomaceæ,	3	3						
Lythraceæ,	7	5	1	1	1		1	
Onagraceæ,	36	26	10	10			10	
Loasaceæ,	1	1						
Cactaceæ,	1	1						
Grossulaceæ,	7	5	2	1			1	
Passifloraceæ,	2	2						
Cucurbitaceæ,	3	3						
Crassulaceæ,	5	5						
Saxifragaceæ,	22	15	4	4	2	2	5	3
Hamamelaceæ,	3	3						
Umbelliferæ,	37	28	9	4	3	2	2	
Araliaceæ,	6	5		1	1	1		
Cornaceæ,	11	10	1					
Caprifoliaceæ,	27	19	7	3	1		3	
Rubiaceæ,	22	18	4	3	1		4	1
Valerianaceæ,	7	6	1					
Compositæ,	273	233	29	11		2	9	
Lobeliaceæ,	12	11					1	1
Campanulaceæ,	5	3	2	1			1	
Ericaceæ,	62	35	21	18	2	1	19	2

Class I—*continued.*

Natural Orders.	Whole number of species in the northern United States.	East'n N. American: not extending westward beyond the Rocky Mountains.	Extending westward to the Pacific coast or near it.	Extending into Asia.	Inhabiting Asia, but not in N. W. America.	Inhabiting Asia, but not in Europe.	Extending into Europe.	Inhabiting Europe, but not in Eastern Asia.
Galacineæ,	1	1						
Aquifoliaceæ,	10	10						
Styracaceæ,	5	5						
Ebenaceæ,	1	1						
Sapotaceæ,	2	2						
Plantaginaceæ,	6	4	2	1			1	
Plumbaginaceæ,	1		1	1			1	
Primulaceæ,	16	8	8	6			6	
Lentibulaceæ,	12	8	2	4			4	
Bignoniaceæ,	2	2						
Orobanchaceæ,	5	2	3					
Scrophulariaceæ,	54	38	15	10	1		10	
Acanthaceæ,	3	3						
Verbenaceæ,	7	5	1	1	1	1		
Labiatæ,	49	42	7	4			4	
Borraginaceæ,	16	12	4	3			3	
Hydrophyllaceæ,	11	9	2					
Polemoniaceæ,	12	11	1	1			1	
Convolvulaceæ,	15	14	1	1			1	
Solanaceæ,	4	4						
Gentianaceæ,	24	22	2	2			2	
Apocynaceæ,	4	3	1					
Asclepiadaceæ,	21	21						
Oleaceæ,	9	9						
Aristolochiaceæ,	6	6						
Nyctaginaceæ,	1	1						
Phytolaccaceæ,	1	1						
Chenopodiaceæ,	10	4	5	5	1		6	6
Amarantaceæ,	5	5						
Polygonaceæ,	22	14	7	6	1		6	
Lauraceæ,	5	5						
Thymeleaceæ,	1	1						
Elæagnaceæ,	1		1					
Santalaceæ,	3	2	1					
Loranthaceæ,	1	1						
Saururaceæ,	1	1						
Ceratophyllaceæ,	1		1	1			1	
Callitrichaceæ,	3		3	3			3	
Podostemaceæ,	1	1						
Euphorbiaceæ,	28	25	3					
Empetraceæ,	2	1	1	1			1	
Urticaceæ,	15	13	2	1			1	

CLASS I—*continued.*

Natural Orders.	Whole number of species in the northern United States.	East'n N. America, and extending westward beyond the Rocky Mountains.	Extending westward to the Pacific coast or near it.	Extending into Asia.	Inhabiting Asia, but not in N.W. America	Inhabiting Asia, but not in Europe.	Extending into Europe.	Inhabiting Europe, but not in Eastern Asia.
Platanaceæ,	1	1						
Juglandaceæ,	9	9						
Cupuliferæ,	25	23	1	1	1		1	
Myricaceæ,	3	2	1	1			1	
Betulaceæ,	10	6	2	4	2		4	
Salicaceæ,	24	18	6	4	1		3	
Coniferæ,	20	13	7	2			2	
Class II. MONOCOTYLEDONÆ, seu ENDOGENÆ.								
Araceæ,	7	5		2	2		2	
Typhaceæ,	7	1	3	5			6	1
Lemnaceæ,	5	1		4			4	
Naiadaceæ,	16	4	4	9	5		12	3
Alismaceæ,	12	5	7	4			4	
Hydrocharidaceæ,	3	1		1	1		2	1
Burmanniaceæ,	1	1						
Orchidaceæ,	51	36	13	9	2	1	10	2
Amaryllidaceæ,	4	4						
Hæmodoraceæ,	4	4						
Bromeliaceæ,	1	1						
Iridaceæ,	6	5	1					
Dioscoreaceæ,	1	1						
Smilaceæ,	18	17	1					
Liliaceæ,	24	14	7	5	1	1	5	1
Melanthaceæ,	21	15	6	1			1	
Juncaceæ,	26	6	16	14	4		14	
Pontederiaceæ,	4	4						
Commelynaceæ,	6	6						
Xyridaceæ,	4	4						
Eriocaulonaceæ,	5	4					1	1
Cyperaceæ,	213	155	37	37	3	2	48	13
Gramineæ,	162	114	44	33	1	4	32	2
Total Monocotyledoneæ,	601	408	143	124	19	8	141	25
Dicotyledoneæ,	1490	1168	273	184	26	17	180	13
Phænogamia,	2091	1576	416	308	45	25	321	38

The data are not at hand for extending this table through the higher Cryptogamia, except for the highest class, and that imperfectly. The four orders of *Vascular* or *Acrogenous Cryptogamia* give the following results; the columns being homologous with those of the last table.

Equisetaceæ,	10	2	8	8			8	
Filices,	49	26	13	23	8	3	20	
Lycopodiaceæ,	12	4	6	7	1	2	6	1
Hydropterides,	4	2	1	1	1		1	
	75	34	28	39	10	5	35	1

These tables necessarily include the species of our small alpine region, which, being chiefly Arctic, might properly be regarded rather as intruded members of the Arctic flora. Being mostly diffused all round the world, they increase somewhat unduly the numbers of our species common to Europe and to Asia; but they are not sufficiently numerous with us to require to be formally eliminated. The following are all the Phænogamous species which, within our limits, are found *only* in our small alpine region, namely, on the summits of the White Mountains of New Hampshire, of Mount Katahdin, Maine, and the highest peaks of the Green Mountains, Vermont, and the Adirondack Mountains in Northern New York:—

Cardamine bellidifolia.
Viola palustris.
Silene acaulis.
Sibbaldia procumbens.
Dryas integrifolia, (fide Pursh).
Potentilla frigida.
Epilobium alpinum, var. majus.
Saxifraga rivularis.
Gnaphalium supinum.
Nabalus Boottii.
Nabalus nanus.
Vaccinium cæspitosum.
Arctostaphylos alpina.
Phyllodoce taxifolia.
Rhododendron Lapponicum.
Veronica alpina.
Diapensia Lapponica.
Oxyria reniformis.
Betula nana.
Salix phylicifolia.
Salix Uva-Ursi.
Salix repens.
Salix herbacea.
Luzula arcuata.
Luzula spicata.
Juncus trifidus.
Carex capitata.
Carex atrata.
Phleum alpinum.
Calamagrostis Pickeringii.
Poa laxa.
Aira atropurpurea.
Hierochloa alpina.

Of these 33 species, two (*Nabalus Boottii* and *Calamagrostis Pickeringii*) are peculiar to our own alpine region, so far as is now known, but they are most likely to occur further north; and two (*Nabalus nanus* and *Vaccinium cæspitosum*) are peculiarly North American. All the rest are European, and with two or three exceptions also Asiatic. No one of our vascular Cryptogamous species is wholly alpine, *Lycopodium Selago* comes the nearest to being so.

The following are with us subalpine species; they occur in our alpine region (to which most of them properly belong), but also out of it, at least in one or two places.

Alsine Grœnlandica.
Geum radiatum.
Arnica mollis.
Vaccinium uliginosum.
Euphrasia officinalis.
Polygonum viviparum.
Empetrum nigrum.
Platanthera obtusata.
Scirpus cæspitosus.
Carex scirpoidea.
Carex capillaris.
Trisetum subspicatum.

All of these except *Geum radiatum*, *Arnica mollis*, and *Carex scirpoidea*, are also European. The last grows in Greenland.

The following European species have not been detected in any properly alpine habitat with us (where they might be expected to occur), but elsewhere, three of them (*Saxifraga aizoides* and *Carex gynocrates*) in stations not even subalpine:

Saxifraga oppositifolia.
Saxifraga aizoides.
Saxifraga Aizoon.
Artemisia borealis.
Juncus Stygius.
Carex gynocrates.

Two Ferns might be added to the subalpine list, viz:—*Woodsia glabella* and *Aspidium fragrans*.

The Phænogamous species whose range, so far as is now known, falls wholly within the limits of the 'Manual of the Botany of the Northern United States' are the following:

Dicotyledonous.	Monocotyledonous.
Dentaria maxima.	Lemna perpusilla.
Vesicaria Shortii.	Potamogeton Robbinsii.
Napæa dioica.	" Tuckermani.
Sida Napæa.	Trillium nivale.
Psoralea stipulata.	Veratrum Woodii.
Astragalus Robbinsii?	Helonias bullata.
Ludwigia polycarpa.	Narthecium Americanum.
Tillæa simplex.	Juncus Greenii.
Sullivantia Ohionis.	Cyperus Grayii.
Galium concinnum.	Eleocharis rostellata.
Fedia Fagopyrum.	" compressa.
" umbilicata.	" Robbinsii.
" patellaria.	Psilocarya scirpoides.
Eupatorium pubescens.	Rhynchospora capillacea.
" resinosum.	Carex exilis.
Solidago Ohioënsis.	" Sartwellii.
" Houghtonii.	" sychnocephala.
" neglecta.	" Crawei?
" Muhlenbergii.	" formosa.
" linoides.	" Careyana.
" Shortii.	" retrocurva.
" rupestris.	" Sullivantii.

Dicotyledonous.	Monocotyledonous.
Rudbeckia speciosa.	Carex mirata.
Coreopsis bidentoides.	" Grayii.
Cirsium pumilum.	Sporobolus compressus.
Nabalus Boottii.	" serotinus.
Gaylussacia brachycera.	Calamagrostis confinis.
Utricularia clandestina.	" Pickeringii.
" resupinata.	" brevipilis.
Hemianthus micranthemoides.	Dupontia Cooleyi.
Pycnanthemum clinopodioides.	Glyceria acutiflora.
" Torreyi.	Poa alsodes.
Asclepias Sullivantii.	" debilis.
" Meadii.	Amphicarpum Purshii.
Blitum maritimum.	
Polygonum Careyi.	
Ulmus racemosa.	
37 species.	34 species = 71.

(*To be continued.*)

Art. XVII.—*Letter on the Museum of Practical Geology of Great Britain;* by Sir Roderick I. Murchison.*

TO THE RIGHT HON. LORD STANLEY OF ALDERLY, &c. &c.

Having heard that Her Majesty's Government proposes to remove the Department of Science and Art, at present under the control of the Board of Trade, to the office of the Minister of the Crown who may be charged with the education of the people, I beg to be permitted to place on record a few observations on the effect which such a change may produce upon the establishment in Jermyn-Street, as consisting of the Geological Survey of the United Kingdom and its affiliated School of Mines and illustrative Museum.

Impressed with the great value of the scheme of bringing science and art to bear upon the productive industry of the country, and anxiously desirous, as well as every professor in this establishment, to aid zealously in so good a cause, I have to request that the following statement may be considered as an exposition of the views entertained by my associates and myself.

I will first recall to your Lordship's notice, briefly, the origin of this establishment and the objects which it was destined to accomplish by the additions which were made to it; and having shown that all other states, seeking to develop their mineral

* From a "Copy of Correspondence between the Director-General of the Geological Survey and the President of the Board of Trade and the Council of Education, relative to annexing a Museum of Practical Geology to the Department of Arts and Sciences."

wealth, have analogous institutions, attention will be drawn to the following points.

First. What real benefits will be derived from our establishment, if it be duly encouraged as a higher School of Mines?

Second. What may result, if it be rendered subordinate to the system of the general education of the country?

It is wholly unnecessary to comment upon the desirableness of a complete geological survey of the British Isles, as first established at the suggestion of my lamented predecessor, Sir Henry De la Beche, which has now been successfully in action for nearly twenty years, and which, whilst it affords the most important information respecting the composition of the sub-soil, has been considered by all persons eminent in geological and mining science, to have been conducted with surpassing skill.

This survey, which is the base of the whole establishment, has its analogue in most civilized lands, and the country void of it must remain ignorant of that knowledge of the crust of the earth which is indispensable in every effort to promote the material interest of man. Acting on this principle, each government of the Great American Republic has its state geologist, just as the continental governments of Europe have colleges and schools specially adapted to the instruction of miners, the chief and active officers of which construct the geological maps of their respective regions.

The object, therefore, of my predecessor was to induce the British government and Parliament to emulate other countries, by adding to the survey an illustrative Museum and a School of Mines; so that England, which, through the spirit and enterprise of individuals, had already taken a prominent lead in geological science, and had seen her own insular names rendered classical throughout the scientific world, might also possess a central school for sound instruction, not only in geology, mining, and mineralogy, but also in the essentially connected sciences of natural history, chemistry, metallurgy, mechanics and physics.

The effects which have resulted from our teaching have been beneficially felt both at home and through the most distant regions, inasmuch as our school has already afforded geological and mining surveyors to many of our colonies in the East Indies, Australia, and the Cape; whilst at this moment the legislature and governments of the West Indies are petitioning for mineral surveyors of their respective islands, and Her Majesty's government joining, as I am happy to say, in this enlightened and liberal movement, have applied to me to recommend suitable persons for such employments.

In relation to Britain, I may be permitted here to suggest, that the encouragement which is now offered to our School of Mines might at once receive considerable stimulus by a declaration on

the part of Her Majesty's government, that no one of the twelve inspectors of coal mines, each receiving a salary of 400*l.* per annum, should be appointed, who had not undergone the preliminary studies which our institution affords. If such and other encouragements were held out abroad as well as at home, and if every person appointed by the crown to all such offices should first either obtain good certificates after studying in our school, or at all events pass a satisfactory examination at it, the number of our pupils would doubtless augment rapidly. Just as scholarships, fellowships, livings and all the higher offices of state and law, are the real attractions which have hitherto filled the ancient universities, so would the public then see that a beneficial career was open to youths through the study of the sciences which we teach.

A really encouraging move, one which has produced the best effects upon our students, has indeed been made in this direction through the enlightened views of His Royal Highness Prince Albert, who, acting for His Royal Highness the Prince of Wales, as Duke of Cornwall, presented to our establishment two scholarships of the annual value of 30*l.* each.

Even in our present condition, nearly 100 officers of Her Majesty's or the Honorable East India Company's services have spontaneously taken advantage of our scientific instruction, which they know will give them advantages in foreign lands; instruction too, which they obtain with us, at half the usual charges, and which cannot be had elsewhere in this country.

Nor let it be supposed that, in any case where a young man is really desirous to gain knowledge, he is not adequately taught; inasmuch as every one of our professors acts both as teacher and examiner, and takes upon himself the tutorial responsibility of ascertaining that he has truly imbued his pupil with sound knowledge.

A striking proof of the interest attached to the useful instruction afforded by our institution is also given by the presence of 600 working men who attend the courses of evening lectures delivered gratuitously by our professors; the tickets being so sought after, that they are applied for and distributed within five hours from the commencement of their issue.

That the publication of the "Memoirs of the Geological Survey" have an important influence, is evident from the fact that, whenever they refer to districts charged with mineral wealth, their publication is speedily exhausted and new editions called for. In alluding to the utility of these publications I beg specially to call attention to a volume about to be issued by our Metallurgical Professor, Dr. Percy, viz., the "Analyses of British Iron Ores." As these results have been obtained in our laboratory and involved in their investigation the elaborate analyses of

all the British iron ores of commercial value, in number amounting to more than 100 varieties, and occupying the time of two chemists incessantly during a period of nearly three years, they prove the extent to which we have been preparing to meet the rivalry of foreign countries, by that close scientific research, the spreading results of which among our industrial population can alone enable us to maintain our present position as the chief manufacturing country in the world.*

Putting aside the consideration of these branches of our studies, the successful cultivation of which is not so obvious to the mass of mankind, but without which no scientific education can be complete, I now pass from the working of our establishment in its present relations to the government, to notice certain impediments to our success as a national scientific establishment, which may arise, if our body should, by a change of relations, be governed by the same influences as those which are likely to prevail in the general management of the education of the people.

Liberal as the minister may be under whose control the general education of the nation may be placed, there is little doubt that in this country the greater number of its instructors will be drawn from among such of the graduates of the ancient universities, as, both by their training and position must be, to a great extent, disqualified from assigning their due importance to the practical branches of science. Such persons may be eminent in scholarship and abstract science, and yet ignorant of the fact that the continued prosperity of their country absolutely depends upon the diffusion of scientific knowledge among its masses. They may, with the most sincere and earnest intention, not only fail to advance, but even exercise a retarding influence on such diffusion, and may object to a course of study which, as now pursued, is irrespective of religious teaching. Experience has shown in how sickly a manner practical science is allowed to raise its head under the direction of those persons whose pursuits are alien to it; whilst in every land, where it has had due support, the greatest benefits have resulted.

Placed as the geological survey and its affiliated branches now are, in subordination to the Board of Trade, they are continually aiding in the development of an amount of mineral wealth far exceeding that of any other country, and in this wholesome and important action, the movements of our body are not only unfettered, but are likely to receive all that encouragement which seems alone to be wanted to enable this establishment to be eminently useful in instructing that class of persons who will materially augment the productive industry and trade of Great Britain.

* *See* Mr. J. Kenyon Blackwell's Paper on the Present position of the Iron Industry of Great Britain, with reference to that of other Countries, read at the Society of Arts, Wednesday 9, January 1856, p. 121 of the Journal.

I have thus taken the liberty of offering to your Lordship, as the Member of Her Majesty's Government under whom I serve, my view upon a subject of which I have long thought; and have only now to request that, in giving it your best attention, you will submit this letter to Her Majesty's Government, and particularly to the consideration of the Minister who may be destined to be charged with the education of the country.

Geological Survey Office, Jermyn Street, Jan. 25, 1856.

ART. XVIII.—*Remarks on the Genus Tetradium, with Notices of the Species found in Middle Tennessee;* by Prof. J. M. SAFFORD, A. M., Geologist of the State of Tennessee.

THE genus *Tetradium*, has been characterized by Prof. Dana in his great work on Zoophytes.* His description and remarks are as follows:

"Coralla massive, consisting of 4-sided tubes, and cells with very thin septa or parietes; cells stellate with 4 narrow laminæ."

"This genus is near Receptaculites, but differs in having very thin parietes and four distinct rays within the cells, one to each side. The specimen answering to the description, is a fossil of uncertain locality in the collections of Yale College, New Haven. The cells are about half a line in breadth. The name, from the Greek, τετρας, *four*, alludes to the quadrate structure."

So far as we know, no further notice has been taken of this genus. To us it is of great interest from the fact that individuals, belonging apparently to several species, are not very abundant in the limestones of the Silurian, or as we shall hereafter term it, the *Central Basin* of Middle Tennessee.

In addition to the characters given above, we add the following: The *tubes*, in the different species, vary from $\frac{1}{4}$ of a line to nearly a line in breadth; they are very long, and are most frequently united throughout laterally, forming massive coralla resembling more or less those of Favosites and Chætetes; sometimes however, they are united in single intersecting series, as in *Halysites catenulatus*, Linn.; not unfrequently too the tubes are isolated, or only united at irregular intervals, thus forming loose fasciculated coralla resembling certain forms of Syringopora.

The *isolated tubes* are nearly quadrangular, the edges being more or less rounded. A slight linear depression down the mid-

* United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842, under the command of Charles Wilkes, U. S. N. Vol. 8th, page 701.

dle of each side externally, opposite the lamellæ. Figure 1 will serve to give an idea of the transverse, or horizontal section of one of these tubes. In the massive specimens the horizontal sections of the tubes are square, or nearly so. In all of the species the walls are more or less rugose.

1.

Separately growing tube of Tetradium; transverse section, magnified 3 or 4 times linear.

The increase appears to be by the division of the tubes, the latter splitting sometimes into two cell-tubes, not unfrequently perhaps into four; opposite laminæ unite and form the new walls of the young cells, each of which is in the mean time supplied with its four rays.

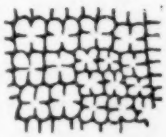
Among the numerous specimens of this genus, which we have seen, we have met with but one which shows clearly the presence of transverse septa. This is a fragmentary specimen of the first species described below. In it the septa are distant about twice the breadth of a tube; but few however are seen, and these are confined to one end of the mass.

This group we regard as being allied in some respects to the *Favositidæ*, while on the other hand, the cruciform arrangement of the lamellæ unite with the *Zoantharia rugosa* of MM. Milne Edwards and Haime; in fact it appears to afford an interesting type of the quadripartite character of the lamellæ, first pointed out, by these distinguished authors, in many palæozoic corals.

We enumerate the following species, all of which as well as the genus itself, so far as we know, are confined to the Lower Silurian rocks.

1. *Tetradium fibratum* Safford, (Fig. 2.)—Coralla massive, hemispherical, or flattened hemispherical, composed of diverging tubes. Cell-tubes four-sided with thin and slightly rugose walls; the four lamellæ distinct, nearly reaching the centre of the tubes; breadth of full-grown tubes usually about, or but little more than, half a line, varying occasionally from $\frac{1}{3}$d to $\frac{2}{3}$ths of a line. Transverse septa usually absent. A few have been seen in one specimen, which were about twice the breadth of a tube apart.

2.



Transverse section of a few tubes of T. fibratum, magnified.

This beautiful species, which may be taken as the type of the genus, occurs abundantly throughout the upper half of the Lower Silurian rocks of Middle Tennessee, associated with *Favistella stellata* Hall, *Ambonychia radiata* Hall, and other Hudson River species. Large masses a foot or two in diameter, are met with. The calcareous specimens often resemble, in a weathered longitudinal section, a fossilized but previously somewhat macerated mass of woody fibre, and hence the name of the species.

2. *T. columnare* Hall; Syn. *Chætetes columnaris* Hall. Pal. of N. Y., vol. i, p. 68, Pl. XXIII, Figs. 4, 4 a—Mr. Hall's species,

we think referable to this genus. It differs from T. fibratum in the following particulars: the tubes are not as uniformly four-sided, nor are they arranged with equal regularity; the walls are more strongly rugose; the lamellæ appear to have been more delicate, and are generally not to be seen; traces of them however can, in most instances, be found upon close examination. The four-sided character of the tubes is sufficiently well marked to justify this reference, in connection with the fact that traces of the lamellæ can often be detected.

This species is associated with the last, and occurs, in addition, lower in the series, with *Columnaria alveolata* Hall. It is a common fossil in our Central Basin.

3. *T. apertum* Safford—Tubes isolated or fasciculated, or else united in linear series which often intersect, forming irregular reticulations; breadth of tubes about half a line; lamellæ as in T. fibratum.

This species includes certain open, loosely constructed corals which belong to this genus. Two varieties may be designated. These appear to run into each other in some specimens, though it may be found necessary hereafter to separate them.

(*a*) Masses composed of separate tubes occasionally united by their sides. These forms often resemble *Syringopora*.

(*b*) Masses composed of tubes arranged in linear series, the latter intersecting and forming masses like those of *Halysites catenulatus* Linn.

Should it be found necessary to separate these varieties, the first may be designated *T. laxum* and the second *T. apertum*.

We have observed no characters, with the exception of the open mode of growth which separate this species from *T. fibratum*.

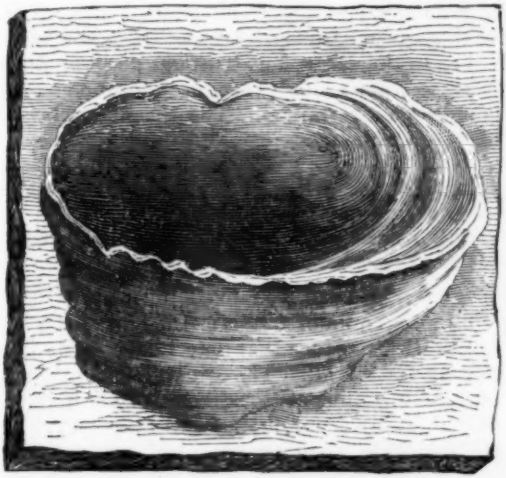
The first variety is abundant in the middle part of the Lower Silurian series of Middle Tennessee. The second is found in the upper half as well as near the base. We have observed the same species in Kentucky.

4. *T. minus* Safford—We include in this species massive specimens, (generally small,) the tubes of which are only from $\frac{1}{4}$th to $\frac{1}{3}$d of a line in breadth. The tubes in some specimens are quite regular, in others, though generally four-sided, are more or less irregular and have the aspect on the upper surface of Chætetes. Lamellæ as in T. fibratum.

We have occasionally seen this species in the upper division of the Lower Silurian series in Middle Tennessee, as well as in Kentucky.

ART. XIX.—*A new Fossil Shell in the Connecticut River Sandstone;* by E. HITCHCOCK, Jr.

I HAVE lately found in the coarse sandstone of Mount Tom, (Easthampton, Mass.,) a shell of a mollusk, the first I believe that has been discovered in the sandstone of the Connecticut Valley. It is preserved and not petrified, and a considerable part of it has disappeared. Enough remains however to enable us to refer it to a family if not to a genus of shells. It is represented in the annexed diagram of the natural size as it lies in



the rock. The upper part is gone, leaving an oval opening about an inch and three quarters in one diameter and an inch and one quarter in the other. It extends downwards, tapering somewhat rapidly nearly an inch and a half, and is left without a bottom, the lower opening being about an inch wide. The walls are very thick, in some places nearly half an inch, and made up of several concentric layers.

From the resemblance of this shell to a model of the lower valve of the Sphærulites calceoloides in the Cabinet of Amherst College, it seems probable that it may be referred to that family of Brachiopods denominated Rudistæ by Lamarck.

Its lower parts as well as the lower valve are missing, but what remains approaches nearer to the genus Sphærulites than to any other of the Rudistæ of which I have seen specimens or figures.

The geological position of this fossil will be readily understood by referring to the description of Clathropteris rectiusculus

as described in vol. xx, p. 22 of this Journal. The shell is found in the same coarse grit as the Clathropteris, immediately beneath the trap (see section in the paper just referred to).

By referring to Bronn's Lethæa Geognostica, I find that the Rudistæ with the exception of the genera—Orbicula and Crania, are confined almost wholly to the Chalk Formation, and the shell from Mount Tom certainly comes nearer to the genus Sphærulites, Radiolites and Hippurites, than to Crania.

This specimen is too imperfect to allow of a specific or generic description, but if there be no mistake in associating it with the above genera, it seems to lend additional strength to the inference derived from the discovery of the Clathropteris, that the upper part of the Sandstone of the Connecticut Valley is as high at least as the Liassic or Jurassic series. It might seem even to carry us higher in the series, but it would be premature to draw such an inference from a single imperfect specimen, even though its true analogies be ascertained. The specimen now belongs to Amherst College Cabinet.

ART. XX.—*On the Eruption at Hawaii;* by Rev. TITUS COAN.*

ERE this you may have seen my letter of Nov. 16th to Mr. Lyman, giving an account of a visit to the end of the lava stream in the forests of Hilo. Since that date I have made four trips to the fire, making six in all. The great fire fountain is still in eruption, and the terminus of the stream is only about five miles from the shore. A track for horses has been cut to the fire, so that we can now ride up with ease and return in half a day. The lava moves slowly along on the surface of the ground, and at points where the quantity of lava is small, we dip it up with an iron spoon held in the hand. During the last three weeks the stream has made no progress towards Hilo, and we begin to hope that the supply at the summit fountain has diminished. There is, however, still much smoke at the terminal crater; and while the lower end of the stream is hardened for two miles above its terminus, thus checking the flow in the forest, the fusion is by hydrostatic pressure, gushing up vertically above this line, and creeping, like fiery serpents, in a thousand gory looking rills, over the smouldering masses of lava, long since deposited. These repeated and numerous up-gushings of the fusion through cracks, holes and fissures in the superincumbent masses of recently solidified lava, are caused by the sudden hardening of the end of the stream, thus obstructing the passage and causing the incandescent material, flowing under cover from regions above, to force

* From a letter to J. D. Dana, dated Hilo, March 7, 1856.

lateral outlets, or burst again to the surface by raising the superincumbent crust into ten thousand tumuli, cracking it in every direction and tilting it at every angle. In this way, the hardened stream becomes an irregularly laminated mass of unequal thickness, with a surface rolling in ridges, raised in blisters, cones, hillocks and domes, depressed into valleys, indented with pits, rent with yawning fissures, frowning with precipices, and bristling with crags. The process is somewhat like that of a superabundant quantity of water forcing its way into too small or obstructed channels under vast fields of ice; allowing, of course, for the great difference in consistency. You will understand, that the molten flood is all poured out of the fissures on the summit and for a few miles down the slope of the mountain. At first, this disgorgement flowed down and spread wide on the surface of the mountain as blood flows down a punctured limb. This phenomenon continued until the stream had swept down some thirty miles, which it did in about two days. It now came upon a plane where the angle of slope was small, say 1°. Here its progress became slow, it spread more widely, and refrigeration was more rapid. The surface, of course, hardened first. But this refrigerating process went deeper and deeper like the congelation of water, and extended higher and higher up the mountain, until at length all the lava was covered, except at occasional vents—as heretofore described—for the escape of steam and gases. Meanwhile the molten river careered unseen under the enormous mural ceiling which had been formed of its own substance, in a continuous longitudinal stream—showing itself in fiery lines, points, rills and capes, as it gushed out from under the black crust at the terminus of the stream. Here we could deliberately note its movements, as it pushed sullenly along over the rocks, through the jungle and into the mud, the pools, and water courses. The process of breaking up vertically and spreading out afresh upon the hardened crust, was occasioned by obstructions at the end of the stream, damming up the liquid, and thus obliging the accumulating lavas to force new passages and outlets for disgorgement. In this way the stream was widened by lateral outgushings, divided into several channels, swayed to the right and left, and raised to great heights by pushing up from below, and heaping mass after mass upon what *had been* its upper stratum. Often when the stream had been flowing briskly and brilliantly at the end, it would suddenly harden and cool, and for several days remain inactive. At length, however, immense areas of the solidified lava, four, five or six miles *above* the end of the stream, are seen in motion—cones are uncapped—domes crack—hills and ridges of scoria move and clink—immense slabs of lava are raised vertically or tilted in every direction, while a

low, sullen crash, is heard from below, as if infernal spirits had risen to the surface of their fiery abyss and were there struggling to burst the adamantine ceiling of their prison and breathe the air of mortals. While you gaze in mute amazement, and feel the solid masses of rock—often 30, 50 or 70 feet thick—moving under your feet, the struggling lava oozes out, through ten thousand orifices and fissures, over a field of some four or five square miles. More than once have I been on such a field, and heard, and seen and felt more than is here or can be described. And yet the action of the lava is so slow—in the conditions described—that there is no fear, and little danger to one well acquainted with such phenomena. While the timid novitiate would flee for miles before such a scene, without looking back, and without consciousness of breathing, the experienced explorer will walk deliberately among the fiery pools, and rills, pry off the caps of bursting tumuli, and dip up spoils from the incandescent rocks.

When the lava becomes obstructed so that it ceases, for a time, to flow from the *end* of the stream, then the process which has been described takes place at some point above, and the molten mass coming up at many points, and accumulating on the surface, moves down in a superincumbent stream or streams, covering up the hardened masses below, deepening the lava, and at length reaching the terminus of the former flow, pushes on into the standing forests, and continues its progress towards Hilo perhaps a mile or so, when this hardens and stops, and at length the process is repeated. Here you see the reason why Hilo has not long since been buried.

Several large tributaries of the Wailuku—the stream which empties into our bay—are blotted out, and the water of the Wailuku is greatly reduced and rendered for the present unfit for use.

Scenes of terrible splendor have been witnessed in some of our river channels, as the molten flood moved resistlessly down, displacing the water, leaping the precipices, and lighting up the banks with immense bonfires of flaming jungle. I have witnessed two scenes of the kind of inexpressible brilliancy. One on the night of the 29th of January, and the other on the 12th of February. During the former night, the molten stream poured continuously over a precipice of 50 feet, into a deep, dry basin, half filled with flood-wood. The angle down which this fire-cataract flowed, was about 75°: the lava was divided into two, three, and sometimes four channels, from one to four yards wide, and two or three feet deep. The flow was continuous down the face of this precipice from 2 P. M. on the 19th until 10 A. M. on the 30th, when we left. During the night the immense basin under the fall was filled, the precipice converted into an inclined plane

of about 4°, and the burning stream was urging its way along the rocky channel below.

But the scene on the night of the 12th of February, was, in some respects, more gorgeous still, as it combined the element of water with that of fire. A stream of lava from 20 to 40 yards wide had followed the rocky and precipitous bed of a river, until it was two miles in advance of the main lava flow, which was nearly two miles broad. Beating our way through the thicket, we came upon the terminus of this narrow stream of lava, near sunset. It was intensely active, and about to pour over a precipice of 39 feet (by measurement,) into a basin of deep water, large enough to float a ship. Before dark, the lava began to fall into the water, first in great broken masses, like clots of blood; but in a short time in continuous, incandescent streams, which increased from hour to hour in volume, in brilliancy and in rate of motion. The water boiled and raged with fearful vehemence, raising its domes and cones of ebullition ten feet high, and reflecting the red masses of fusion like a sea of fire mingled with blood.

The evaporation was rapid and sublime. From the whole surface of the basin, a vast irregular column of vapor rose and rolled upward in fleecy wreaths, and hung in a gilded and glorious canopy over the dark forest and over the fiery abyss. All night long the scene was ever changing and yet unchanged. The convolutions and gvrations were constant and inimitable. Sometimes the fleecy pillar would roll up vertically, until it seemed to form an entablature for the great dome of heaven. Again, it would career off upon the winds, like a glorious galaxy, or break up in delicate tumuli to adorn the midnight sky. We encamped on the bank of the river, about fifty feet below the fiery cataract, and exactly opposite the basin of water into which the lava was flowing, 20 feet only from its rim. The face of this precipice was an angle of about 80°, and the lava flowed down it briskly and continuously, in streams from one to four feet deep, during the night. Before morning this whole body of water, some 20 feet deep, was converted into steam, and the precipice became a gently inclined plane. In a few hours more the action ceased at this point and it has not been again renewed.

I have seen continuous lava streams flow rapidly down the sides of the mountain from 10 to probably 50 feet deep. Lava flows at any depth, or any angle, and at any rate of progress from 20 feet an hour to 40 miles.

March 17.—The lava has made no progress towards us since the date of this letter.

ART. XXI.—*On the purification of Amorphous Phosphorus;* by M. ERNEST NICKLES

IT is known that the phosphorus not spontaneously inflammable or amorphous phosphorus (called also red or allotropic phosphorus), is obtained by heating common phosphorus for some time at a temperature between 230° and 250° C., in an atmosphere of nitrogen, hydrogen, or other gas free from oxygen. But however long the treatment be continued, a portion of the phosphorus always escapes the change and must be removed, if we would not compromise the essential qualities of the amorphous phosphorus, its innocuity and its unalterability in the air. The mode of purifying it proposed by Schrötter, its discoverer, is very inconvenient. It is based on the use of sulphuret of carbon which dissolves ordinary phosphorus without acting on the other. The process theoretically seems to be a simple one; but it is in practice attended with much trouble and danger; for the washings are not only interminable and require a large quantity of the sulphuret of carbon, but besides this, the chances of inflaming it increase rapidly with the proportions of phosphorus under treatment. M. Schrötter has from the first sought to remove the danger by recommending that the filter be kept full of the sulphuret so that the ordinary phosphorus which deposits on the borders of the filter, in a fine state of division, shall not take fire. But this precaution does not always suffice to prevent accidents.

Impressed with these difficulties while experimenting with the red phosphorus, I have sought, by a study of the distinctive qualities of the two kinds of phosphorus to arrive at a safer and more expeditious mode of preparation; and as the attempts hitherto made have appealed to methods purely chemical, I have looked more particularly to the physical properties of the two bodies. In this way, I have arrived at a process, which is both simple and rapid, and may be trusted even to inexperienced hands—the last a thing of importance since red phosphorus has become an article of commerce.

This process depends on the different specific gravities of the two kinds of phosphorus. It consists in putting the mixture into a liquid of intermediate density: thus, the specific gravity of red phosphorus is 2·106, of ordinary phosphorus 1·77; taking now a saline solution of specific gravity between these,—a solution of chlorid of calcium of 38 to 40 B., answers well the purpose,—the lighter ordinary phosphorus floats on the surface while the heavier red phosphorus remains below; and the former is readily taken up by a little sulphuret of carbon which dissolves it, so that the operation can be performed in a closed vessel.

The following are the details of the process. A little sulphuret of carbon is introduced into the retort in which the transformation has been effected. If the material, which usually adheres strongly, does not detach itself, the bottom of the retort is put into warm water. The disaggregation of the material takes place immediately, and is attended with a slight noise. As soon as the phosphorus is detached, the saline solution is added; the vessel is then closed and shaken, and at the end of ten minutes the separation of the two is accomplished. If the ordinary phosphorus is only one fourth of the whole, it may be removed entirely at a single washing in the manner explained, although it it is more prudent to make a second trial, decanting first the phosphuretted sulphuret of carbon, and adding another quantity of the pure sulphuret: and this is quite necessary if the two kinds of phosphorus are mixed in equal proportions. Three washings of this kind, will remove every trace of the ordinary phosphorus, however large the proportion.

After separating the two liquids by decantation, it is only necessary to turn upon a piece of linen cloth, the saline solution containing the red phosphorus. The purity of the product is so perfect, that it is useless to boil it with a solution of caustic potash, the common method. The whole is completed in half an hour; and what is also important, it is attended with no danger, for the operation by being carried on in a close vessel, does not allow of the vaporization of the sulphuret of carbon and a deposition of the inflammable phosphorus.

Recent observations have shown that the inhalation of the vapor of sulphuret of carbon is not without injury to the health; workmen employed in the caoutchouc manufacture have suffered severely through this means. Still this sulphuret is the best known solvent of phosphorus. The process proposed has a double advantage from this point of view, it diminishing the quantity of sulphuret of carbon used and the chances of its inhalation.

Chemists will see the value of the mode of separating solid substances of different specific gravities, mentioned above—a method not requiring heat nor a direct solvent, and being both easy and expeditious.

ART. XXII.—*Third Supplement to Dana's Mineralogy;* by the Author.*

SINCE the last Supplement was issued, but few new species have been proposed and several of these are of doubtful standing. The work of Professor Scacchi of Naples on the recent eruption of Vesuvius (1855) contains many facts of special interest, respecting the minerals produced at that time; and one of the varieties mentioned is an example of remarkable crystallization. The crystals are octahedrons of magnetite implanted on scoriaceous lava; but they are intersected throughout in the four cleavage directions by laminæ of hematite (specular iron). These laminæ are thin crystals and have regular facets on the edges, although so delicate as to require a glass to distinguish them. Having received specimens from Professor Scacchi, the author can attest to their perfection and the exact parallelism of the laminæ to the faces of the octahedron.

In American mineralogy, there has been the publication of some geological reports containing information on useful minerals and ores, and a few articles in the Journals. The only new minerals have been announced in a mining report, and in this volume (p. 96), by Prof. C. U. Shepard.

It is a matter of regret that mineral species are so often brought out, especially in this country, without sufficient investigation and full descriptions. It is not meeting the just demands of the science of mineralogy to say that a mineral has *probably* certain constituents, or to state the composition in a general way without a complete and detailed analysis; especially when there are no crystallographic characters to afford the species a good foundation. We have a right to demand that those who name species, should use all the means the science of the age admits of, to prove that the species is one that nature will own, for only such belong to science: and if enough of the material has not been found for a good description, there is not enough to authorize the introduction of a new name in the science. The publication of factitious species, in whatever department of science, is progress not towards truth, but into regions of error; and often much and long labor is required before the science recovers from these backward steps.

1. *List of New Works.*

Dr. CARL FRIEDRICH NAUMANN (Liepzig): Elemente der theoretischen Krystallographie, 384 pp., 8vo, with 86 wood-cuts. Liepzig.—This volume is properly a supplement to the former one (Anfangsgrunde der Krystallographie) published in 1854. In that, the elements of the science are explained and the formulas for calcu-

* For Supplements I and II, see this Journal, xix, 353 (May, 1855), and xxi, 193 (March, 1856). The paging inserted beyond, refers to the Mineralogy.

lations are given. This new work gives the mathematical demonstrations, commencing with the principles of analytical geometry. The two were more conveniently incorporated in one work, in Naumann's 2nd edition of his Crystallography published in 1830. Naumann is the best author on the science of Crystallography.

———: Elemente der Mineralogie, 4th ed., 480 pp. 8vo. With 398 wood-cuts. Liepzig. 1855.

A. Dufrenoy: Traité de Minéralogie, 2me edit. considerablement augmentée. Tome 2 et Tome 5, 1ere partie, et Atlas de 80 planches. 8vo. Paris, 1856.

Chevalier Fr. von Hauer & Fr. Fœtterle: Coup d'œil geologique sur les Mines de la Monarchie Autrichienne, rédigé par order de l'Institut Impérial et Royal de Géologie, avec une introduction par M. Haidinger.—252 pp. large 8vo, Vienna, 1855.

G. H. Otto Volger: On Leuchtenbergite and its associates, Hydrargillite, Garnet, Perofskite, Magnetite, Talc-apatite, &c. Pogg. xcvi. 414 and 559. Contains observations on the analyses by other authors, with some deductions that require more investigation to give them currency.

Theodor Kjerulf (Adjunct an der Univ. Christiania): Das Christiana-Silurbecken, chemisch-geognostisch untersucht. Auf Veranstaltung des Academischen Collegiums herausgegeben von A. Strecker. 68 pp. small 4to., with a geological chart.—This work treats of the Silurian geology of Christiania, and especially from a chemical point of view, giving many analyses, (of granites, porphyries, syenites, traps, etc.) and the bearing of the subject on the origin of the rocks.

Dr. Gustav Georg Winkler: Die Pseudomorphosen des Mineralreichs. 136 pp. 8vo. München: 1856. J. Palm.—A clear and systematic review of the subject of pseudomorphism. The author recognizes two kinds of pseudomorphism: that due to *alteration* of the original material, and that due to *substitution* of one mineral for another; the first produced mainly through atmospheric agencies, infiltrating waters, and ingredients of the soil; the second through solution, the less soluble species being in solution and replacing the more soluble. He objects to regarding the instances of a change of a dimorphous substance from one state to the other (such as that of aragonite to calcite, while still retaining the aragonite form) as pseudomorphs. He also takes no notice of those pseudomorphs which arise from one mineral covering or encasing another and copying in reverse its exterior form, or from filling a cavity once occupied by a crystal. Each of these kinds merits at least brief mention in a complete work on the subject. The cubic quartz produced by incrusting or covering over fluor is a common example; the form is pseudo-crystalline: and several other pseudomorphs supposed to be produced by substitution through solution, may have been a result of this moulding process. The decomposition of pyrites leaves a cavity which another infiltrating mineral may fill, taking its form and surface striæ.

A. Scacchi: Memoria sullo Incendio Vesuviano del mese di maggio 1855, fatta per incarico della R. Accad. delle Sci. dai Socii G. Guarini, L. Palmieri, ed A. Scacchi, preceduta dalla relazione dell' altro incendio del 1850, fatta da A. Scacchi. 268 pp. 4to. with 6 plates. Napoli, 1855.

J. A. Hugard: Muséum d'Histoire Naturelle: Galerie de Minéralogie et de Géologie, Descriptions des Collections, Classement et Distribution des Minéraux, Roches, Terrains, et Fossiles, etc. 190 pp. 16 mo. Paris: 1855.

G. C. Swallow: First and Second Annual Reports on the Geological Survey of Missouri, 204 and 240 pp. 8vo, with plates and sections. Besides the Report of Mr. Swallow, there are also the reports of Dr. Litton and Messrs. Meek, Hawn, and B. F. Shumard. Dr. Litton is chemist to the survey, and his report contains many analyses of limestones, iron ores, etc. (vid. this Jour., xxi, 427).

Jas. M. Safford: Geological Reconnaissance of the State of Tennessee, being the author's first biennial Report. 164 pp. 8vo. Nashville, Tenn., 1856. Contains information on the ore beds or veins of the State, of Iron, Copper, Lead, Zinc.

There are four iron ore regions; (1) the *Eastern*, running through the State (Johnson, Carter, etc. Counties) in front of the Unaka group of mountains; (2) the *Dyestone region* skirting the eastern base of the Cumberland and Walden's ridge from Virginia to Georgia, including the Sequatchee and Elk valleys; (3) the *Cumberland*, associated with the coal measures, in the northern part of the State; (4) the *Western*, occupying a strip about 50 miles wide of the western part of Middle Tennessee, running from out of Kentucky to the Alabama line associated with the lower member of the carboniferous limestone. In the 1st, there are Limonite, Hematite and Magnetite ores; in the 2nd, stratified iron-stone; in the 3rd, clay iron-stone; in the 4th, limonite.—Copper ores occur at the Ducktown mine; traces are found elsewhere but no other locality of importance has been discovered.—Galena is found in various parts of East Tennessee, usually associated with blende; also in middle Tennessee.—Calamine is found in East Tennessee, and the ore of Claiborne has long been known. At several places, the mines promise to be of value.—*Gold* exists sparingly in southeast Tennessee, in Blount Co., a few miles east of Montvale Springs back of Childowee Mountain; in Monroe, on the waters of Citico creek, in the bed of Cane creek, on the head waters of Tellico river, and on those of Coco or Coqua creek, also in Polk Co. In 1847, the gold deposited at the U. S. mint amounted to $2 511; in 1848, $7,161; in 1849, $5,180; in 1851, $2,377; in 1852, $750; in 1853, $149; in all, since 1831, $46.023.

Silver glance has been found in two localities, both now doubtful. The specimen reported by Dr. Troost, according to the author, probably came from the Carboniferous limestone, on or near the Calf-killer creek.

Localities of coal, marble, hydraulic limestone, and other products are mentioned in the volume.

W. Kitchell (New Jersey State Geologist): Second Annual Report of the Geological Survey of New Jersey. 248 pp. 8vo., Trenton, 1856.—The iron and zinc mines of the State are described with much interesting detail. At Mt. Hope tunnel, Mr. Wurtz detected a mineral which he has not yet examined, but announces as probably new (p. 192).

C. U. Shepard: Report on the Canton Mine, Georgia. 20 pp. 8vo., 2nd edit. New Haven, 1856.—Contains an account of the minerals of the mine, with indications of three supposed new species called Harrisite, Hitchcockite, and Cherokine.

2. *Crystallography, Formation of Minerals, etc.*

Furnace Products: Hausmann mentions (Soc. Sci. Gott. Nov. 1855) that Manganblende occurs along with the cyano-nitrid of titanium, both in the furnaces of Gleiwitz, and the Royal Mines of Silesia; and Wöhler reports the same from the Hartz. They had been taken for magnetic iron. They occur in the scoria which forms in the working of the blast furnaces. The crystals are usually in distinct octahedrons, 4 to 5 millimeters in diameter. The color when fresh, is iron-black, and the lustre imperfectly metallic; but becoming brownish-black at surface on exposure. It differs from the native manganblende in being strongly attracted by the magnet, and also in giving the reactions of iron as well as manganese before the blowpipe. B.B. it fuses with very great difficulty to a brownish-black scoria.

On some pseudomorphs of iron ores, by E. F. Glocker, (Pogg. xcvi, 262). The paper describes pseudomorphs of hematite (specular iron) after magnetite; earthy red iron ore after hematite; limonite after magnetite; limonite after hematite, and hematite after limonite; of limonite after spathic iron; of limonite after pyrites and marcasite; of hematite after pyrites. He mentions crystals of the form of magnetite from near Schönberg in Moravia, which are altered to specular iron. The octahedrons have the cleavage of the magnetite. They are similar to the so-called martite, or octahedral specular iron of Breithaupt.

Goniometer for the measurement of angles of crystals and for optical purposes, with a plate. W. Haidinger. Pogg. xcvii, 590.

3. *Descriptions of Species.*

ALLANITE [Min. p. 208, and Suppl. I, II].—Description and analysis of Allanite from Norway, by D. Forbes and T. Dahll (Nyt. Mag. f. Nat. xiii, 213). At Helle, in crystals sometimes 4 inches long and ½ to 1 in. thick, with quartz and mica; many of them decomposed and unaltered massive specimens have H.=6, G.=3·46—3·48. Specimen from Näs Mine, occurring in red orthoclase, gave H=6, G.=2·86—2·93, a greenish-black color and greenish-gray streak, and afforded on analysis:

Si̇	Cė	Bė	Al̇	Fė	La, Di̇	Ẏ	Cȧ	Ḣ	
31·03	7·24	3·71	9·29	22·98	4·35	1·02	6·39	12·24	alkali and loss 1·75

Allanite occurs at Criffel in Scotland in small crystals in syenite and feldspathic granite; *R. P. Greg, Jr.*

ALUM [p. 382].—Occurs in the caves of the Unaka Mts., Eastern Tennessee, especially at Sevier, where masses of a cubic foot may be obtained; also in the *black slate* of Middle Tennessee; in caves along the valleys and gorges of the streams in DeKalb, Coffee, Franklin, and other counties.—Safford's Rep., p. 118.

ALUNOGEN [p. 381].—Occurs at Vesuvius with alum, Scacchi, op. cit., p. 194.

A white fibrous alunogen (?) occurs abundantly at Smoky Mountain, Jackson Co., N. Carolina. According to Mr. Faber, there are tons to be blasted at that locality. —(Prof. J. C. Booth, in a letter to the author.)

ALVITE. *D. Forbes* and *T. Dahll* (Nyt. Mag. f. Nat. xiii).—From Helle and Narestö in Norway. In dimetric crystals like zircon. Fracture splintery. H.=5·5. G.=3·601—3·46. Color reddish brown, becoming grayish brown by alteration. Lustre greasy; opaque, on the edges translucent. B.B. in the platinum infusible, color somewhat paler. With borax a glass greenish yellow while hot, colorless when cold. With salt of phosphorus a yellow glass, green, and finally colorless on cooling. With tin no titanium reaction. In fine powder, not attacked by the acids. An analysis of the mineral on a very small portion and part of it somewhat altered afforded

Si̇	Al̇, Bė	Fė	Z̈r	Cė	Ẏ	Th (?)	Cȧ	Cu, Sn	Ḣ	
20·33	14·11	9·66	3·92	0·27	22·01	15·13	0·40	*trace*	9·32	=97·24

ANDALUSITE [p. 257 and Suppl. I, II].—Analysis (1) of the Andalusite of Katharinenberg near Wunsiedel, (2) of Robschütz near Meissen, and (3) of Bräunsdorf near Freiberg, by E. E. Schmid, (Pogg. xcvii, 113):

	Si̇	Al̇	Fė	Cȧ	Ṁg			
1.	35·74	56·98	5·71	0·15	0·20	=	98·78	G. =3·12
2.	36·84	55·82	3·22	1·09	1·14	=	98·11	G. =3·11
3.	37·57	59·88	1·33	0·61	0·17	=	99·56	G. =3·07

Oxygen ratio for the silica and sesquioxyds (1) 2 : 3·06, (2) 2 : 2·77, (3) 2 : 2·86, corresponding nearly to the formula $\dot{A}l^3\ \dot{S}i^2$. [Allowing that the protoxyds are combined with part of the silica, Nos. 2 and 3, will give much more nearly the ratio 2 : 3.]

ANGLESITE [p. 370, and Suppl. II].—Kokscharov figures a fine crystal of Anglesite from Monte Poni, Sardinia (Min. Russl. ii, 168). He mentions the occurrence of the planes $\breve{a}\frac{1}{4}$, $1\breve{2}$; and gives the angles $I : I$=103° 43½′, $O : 1$=115° 35½′.

APATITE [p. 396, and Suppl. I, II].—Occurs in New Jersey, at Mt. Pleasant Mine, near Mt. Teabo, in a low hill near the junction of the Rockaway River and the Burnt Meadow Creek, and about three-fourths of a mile from the canal. The masses are sometimes 6 inches in diameter. Apatite is also abundant with the magnetite of Byram mine.—N. J. Geol. Rep. 1856.

ARAGONITE [p. 448, and Suppl. II].—Pseudomorphs of the scaly massive carbonate of lime (called *Schaumkalk* in German) after gypsum are described by G. Rose in Pogg. Ann. xcvii, 161. Near Wiederstädt in Mansfeld, a fine-grained gypsum

contains selenite in large plates which are partly altered to this earthy carbonate. Bischof has explained the change by supposing that waters holding carbonate of soda in solution have filtrated through, producing with the gypsum sulphate of soda and carbonate of lime; but he and others have regarded the carbonate as common calcite. Prof. Rose adds to the examples of the change and shows that the carbonate is aragonite. It is generally snow-white and opaque, but minute scales are transparent; and sometimes minute crystalline tables may be distinguished. These tables have the form and angles of aragonite. Specific gravity 2·984 at 15° R.

An important paper on the groupings in the twin crystals of Aragonite, Witherite and Alstonite, by M H. de Senarmont, is contained in the Ann. de Ch. et de Phys. [3], xli, 60. The structure of the crystals was determined by means of polarized light.

ASTROPHYLLITE, *Scheerer.*—A kind of mica, from Brevig, Norway. Color black and also bronze to gold-yellow; lustre submetallic. Crystals 6-sided prisms and tables, elongated in the direction of the clinodiagonal. The angle of the prism, as usual with the micas, near 120°. Laminæ but little elastic. Contains $\dot{S}i$, $\dot{F}e$, $\dot{A}l$, $\dot{F}e$, $\dot{M}g$, $\dot{K}$, $\dot{N}a$, $\dot{M}n$, $\dot{C}a$, and about 3 per cent of water with no fluor.

ATACAMITE (?) [p. 138, and Suppl. I].—Prof. Scacchi questions the occurrence of true atacamite at Vesuvius (op. cit., p. 197). The supposed atacamite occurs (1) in slender filaments of vitreous lustre and grass green color; (2) in clustered acicular opaque crystals, between brownish green and pale bluish green; (3) in an opaque crust, with rough surface and emerald-green color; (4) in a very thin crust, of a fine emerald-green color. The first variety which seems to be the purest passes into the second.

Prof. Scacchi concludes from his various trials, that the mineral does not contain chlorine; that its composition is not constant; that ordinarily on immersing it in water, it affords an insoluble salt of a bluish color, which dissolves in nitric acid and affords reactions of sulphuric acid and copper, and may be a basic sulphate of copper.

BINNITE [Suppl. II].—This mineral which occurs with the dufrenoysite in the dolomite of Binnen, is described by Ch. Heusser, in Pogg. xcvii, 120. Crystallization, trimetric. Occurring forms prismatic, striated longitudinally, the prism *I*, having the acute edges replaced by *ĭ*, and the brachydomes, $\frac{1}{2}\breve{1}$, $1\breve{1}$, $\frac{3}{2}\breve{1}$, $2\breve{1}$, with sometimes *O*, 1, *ĭ*, and a macrodome Basal angle of the dome $\frac{1}{2}\breve{1}$, 43° 52′; of $1\breve{1}$, 77° 32′; of $\frac{3}{2}\breve{1}$, 100° 38′; of $2\breve{1}$, 116° 12′. Color pale or dark steel-gray to black; streak-powder uniformly a darker red than that of the dufrenoysite; very brittle; fracture perfect conchoidal.

BORACITE [p. 393, and Suppl. II].—The massive boracite of Stassfurt, which differs from true boracite in its ready solubility in acids, and its easier fusibility, has been named *Stassfurtite* by G. Rose (Pogg. xcvii, 632). The solution in heated muriatic acid deposits after a while, hydrated boracic acid. The masses are not properly structureless but have a columnar composition and the system of crystallization probably is not monometric. Chemically, boracite and stassfurtite according to the analyses, give the same formula; and if so, the two are an example of dimorphism. H. Rose has new analyses under way; and other examinations of specimens may clear up the doubts on the subject.

BORONATROCALCITE [p. 394].—Analysis of this mineral from near Iquique, S. A., by Rammelsberg (Pogg. xcvii, 301):

$\dot{B}$	$\dot{C}a$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
43·70	13·11	6·67	0·83	35·67	= 100

3·17 p. c. of chlorid of sodium, 0·41 sulphate of soda, and 0·39 of sulphate of lime obtained in the analysis being excluded. This gives the formula $\dot{N}a\dot{B}^2+2\dot{C}a\dot{B}^2+18\dot{H}$. The Hayesine, similar in physical characters, which Hayes analyzed, gave him the composition $\dot{C}a\dot{B}^3+6\dot{H}$.

BRAGITE, *D. Forbes* and *T. Dahll* (Nyt. Mag. f. Nat. xiii).—In indistinct, probably dimetric crystals, imbedded in orthoclase, and found near Helle, Narestö, Alve, and Askerö, Norway. Fracture uneven. H.=6—6·5. G.=5·13—5·36. Color

brown; streak yellowish brown. Lustre semi-metallic. Thin splinters translucent. Decrepitates strongly and loses water. B.B. in the platinum forceps infusible, but becomes yellow: with borax, a glass which is brownish yellow while hot, but green and finally greenish yellow on cooling. In salt of phosphorus, a skeleton of silica.

BREUNNERITE [p. 443].—The Tautoclin of Breithaupt, occurs (N. Jahrb. f. Min. etc., 1855, 842) in scalenohedrons, R^3, or $R^3.\frac{1}{2}R^3$, as pseudomorphs after calcite. Occurs in the Himmelsfurst mine, near Freiberg; also near Sachsenburg, Schneeberg, Przibram in Bohemia, &c. Ettling obtained for the tautoclin of Beschert-Glück, near Freiberg:

$\dot{C}$ 45·75 $\dot{C}a$ 27·48 $\dot{M}g$ 15·85 $\dot{F}e$ 9·25 $\dot{M}n$ 1·29 = 97·62

CALCITE [p. 435, 503, and Suppl. I, II].—A variety of curved columnar calcite from Freiberg in Saxony, according to Kenngott (Pogg. xcvii, 311) has each column made up of a series of tabular crystals $-\frac{1}{2}R.\infty R$ [of the form in fig. 574 C, p. 435 of Min., only very short] united in the line of the vertical axis. The diameter is mostly 2 or 3 millimeters.—Other peculiar forms of grouping and modes of structure are described in the same paper.

CARNALLITE, *H. Rose.*—Description by H. Rose (Pogg. xcviii, 161). Occurs mixed with the stone salt of Stassfurt in coarse granular masses, having a shining somewhat greasy lustre, and sometimes showing a plane surface after the action of water over the surface, as if indicating structure or cleavage, but without any distinct traces of it in a fresh fracture. Dissolves easily in water. Composition according to Mr. Oesten, assistant to Prof. Rose:

	Mg Cl	K Cl	Na Cl	Ca Cl	Fe (mixed)	Ḣ (loss)	
1.	31·46	24·27	5·10	2·62	0·14	35·57 =	100
2.	30·51	24·27	4·55	3·01	0·14	36·26 =	100

The water by direct determination was 37·27. Part of this water is united to the chlorid of calcium, 2·54 p. c. in No. 1, and 2·91 in No. 2; so that the water of the pure mineral is reduced to about 33 per cent. The composition then becomes K Cl + Mg Cl + 12H.

The name *Carnallite* is after Mr. von Carnall of the Prussian Mines.

CHALCOPYRITE [p. 68 and Suppl. II].—An account of the Cobre Lode of Santiago de Cuba, by D. T. Ansted, is contained in the Quart. Jour. Geol. Soc., xii, 144.

CHALYBITE [p. 444].—On the origin of the carbonate of iron in the Coal Measures, W. B. Rogers, Proc. Bost. Soc. Nat. Hist., 1855, 283, and Am. J. Sci., xxi, 339.

CHEROKINE, *C. U. Shepard.*—A species as yet imperfectly described by the author. Crystallizes like pyromorphite but has the color of carbonate of lead. Specific gravity, 4·8. Stated to contain phosphate of alumina and zinc. [The form given, near pyromorphite, would suggest the improbability that the mineral is a phosphate of a sesquoxyd with zinc, unless a pseudomorph.—J. D. D.]

CHLOROPHANERITE, *G. Jenzsch.*—From the amygdaloid in the vicinity of Weissig. It had been referred to chlorophæite, and ferruginous chlorite (Delessite), but differs in its very large percentage of silica. G. Jenzsch obtained (N Jahrb f. Min. etc., 1855, 798,) in a partial analysis, Silica 59·4, protoxyd of iron 12·3, water 5·7, the alumina, magnesia, lime, potash, soda, undetermined.—Color blackish-green; streak dirty apple green; soft; G. = 2·684. BB. yields easily a magnetic glass. In muriatic acid dissolves readily, the silica separating. According to Dr. Oschatz, the particles of a crystalline group magnified, showed slight double refraction. It approaches nearest a green earth from Iceland analyzed by von Waltershausen, which gave, $\dot{S}i$ 60·085, $\dot{A}l$ 5·280, $\dot{C}a$ 0·095, $\dot{M}g$ 4·954, $\dot{F}e$ 15·723, $\dot{K}$ 5·036, $\dot{N}a$ 2·514, $\dot{H}$ 4·444 = 98·131 (Vulk. Gest., p. 301).

CHRYSOLITE [p. 184, and Suppl. I, II].—A mineral looking like some kinds of amorphous garnet, occurs at Pfunders in the Tyrol, in a talcose serpentine rock traversed by veins of calcite. A specimen in the collection of M. Adam of Paris

has been analyzed by M. A. Damour and shown to be *Chrysolite.* He obtained (L'Institut, No. 1148, xxiv, 4, Jan. 1856):

	$\dot{S}i$	$\dot{T}i$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	$\dot{H}$
	36·30	5·30	49·65	6·00	0·60	1·95=99·80
Oxygen,	18·85	2·11	19·50	1·79	0·13	1·73

The silica and magnesia have the oxygen ratio 1 : 1, as in chrysolite. But the exact condition of the titanic acid is not ascertained. [This mode of occurrence of chrysolite is analogous to that of the Boltonite (chrysolite) in granular limestone, and the Glinkite (another variety) in talcose slate. May it be that the titanium is due to a mixture with titanic iron?—D.]

Conistonite and Heddlite [p. 465, and Suppl. II].—According to R. P. Greg, Esq., in a recent letter to the author, these two species, though curious in themselves, have been found to be artificial.

Copiapite [p. 387 and Suppl. I].—Analysis of fibrous copiapite (stypticite) from Copiapo, Chili, by E. Tobler (Ann. Ch. u. Pharm. xcvi, 383): Sulphuric acid 31·49, sesquoxyd of iron 31·69, water 36·82 = 100.

Coquimbite [p. 380].—Observed rather abundantly by Scacchi about fumaroles after the eruption at Vesuvius in 1855 (op. cit., p. 195). Part of it is in a brownish friable crust; obtained by dissolving the saline crust and evaporating, in brownish-yellow *hexagonal* crystals. Also as a yellowish crust, in many parts tinged green, compact in texture, and with a very bright lustre in the fresh fracture.

Cryolite [p. 97 and Suppl. II].—J. W. Tayler, Esq., has given a description of the mode of occurrence of cryolite in Greenland, with wood-cut illustrations, in the Quart. Jour. Geol. Soc. xii, 140. The locality is at Evigtok, about twelve miles from Arksut, on the Fiord of that name. The rock is gneiss and granitic gneiss. It is intersected by a vein of quartzrock containing coarsely crystallized feldspar, cryolite, and ores of iron, tin, lead, zinc, tantalum, etc., running about southwest, besides other small veins and masses of cryolite; and to the east and west there is a trap-dyke. The main mass of cryolite forms a bed or vein parallel to the strata, running nearly east and west, dipping S 45°, and is about 80 feet thick and 300 long. It is bounded along the walls by a band of spathic iron, quartz, and in some parts by fluor and galena, while near the walls in the cryolite there are more or less galena, copper and iron pyrites, etc. Tantalite and cassiterite occur in the cryolite. The galena contains 45 oz. of silver to the ton and is worked. In its lower part the cryolite is black, and the white color of the upper part is attributed to exposure to heat. The author infers "that the trap now found at each end of the cryolite has formerly overlain it, heating it superficially and rendering it white."

CYANOCHROME, *Scacchi.*—A sulphate of potash and copper, among the products of Vesuvius, at the eruption of 1855 (op. cit., p. 191).—In clear blue crystals obtained by dissolving and evaporating the saline crust, from the lava of Vesuvius; also in azure blue spots upon the white crust. Composition $(\frac{1}{2}\dot{K} + \frac{1}{2}\dot{C}u)\,\ddot{S} + 3\dot{H}$.

Form of crystals monoclinic. C (or inclination of vertical axis) = 75° 30′.

Occurring planes, O, $1i$, $2i$, ii, 1, I, $2\breve{2}$, $1\breve{i}$. $O : ii = 75° 30'$, $O : 1i = 153° 56'$, $O : 1\breve{i} = 141° 47'$, $O : 2i = 116° 49'$, $I : I = 108° 12'$.

Cyanosite [p. 380].—Observed at Vesuvius by Scacchi, among the products of the eruption of 1855. Op. cit., p. 189.

Analysis of a specimen from Copiapo, Chili, by E. Tobler (Ann. Ch. u. Pharm. xcvi, 383): Sulphuric acid 32·41, oxyd of copper 30·77, water (as loss) 36·82=100. Occurs with stypticite and both results from the decomposition of chalcopyrite.

Datholite [p. 334 and Suppl. I, II].—F. Schröder has made many new measurements of Datholite crystals (Pogg. xcviii, 34), and concludes from them that the form is monoclinic, with the inclination of the axis, 90° 7′. He figures a crystal having the planes in the annexed table.

			O			
$2i$				$2\breve{2}$	$2\grave{4}$	$2i$
$4i$			$4\frac{4}{3}$	$4\breve{2}$	$4\grave{4}$	$4i$
ii		I		$i\breve{2}$		
		-4				$4i$
	$-3\frac{3}{2}$					
$-2i$		-2				$2i$

Andreasberg.

		O		
$1i$				
$2i$				$2i$
	$3\grave{3}$			
		4		$4i$
$6i$	$6\grave{3}$			
			$8\breve{2}$	
ii		I	$i\breve{2}$	
				$4i$
$-2i$		-2		$2i$
		$-\frac{4}{3}$		
		-1		
		$-\frac{3}{4}$		

American.

[The symbols, for convenience of comparison, are made to correspond with those in the Min p. 335; by substituting for the values of the axes $a : b : c$, $2a : b : \frac{1}{2}c$, they are converted into those of Schröder. To show farther the relations of the American crystals (figs. 489, 490, 491, 493 of Min.) a table of the planes is added, the form being taken as monoclinic. In the American crystals, the prism of 115° 26′ (I) is the dominant one, while in those of Europe, that of 76° 44′ ($i\breve{2}$) is dominant.]

Schröder gives the following values to some of the angles; $I : I = 115° 19'$, $i\breve{2} : i\breve{2} = 76° 36'$, $2\breve{2} : 2\breve{2}$ (front) $= 120° 58'$, $-2 : -2$ (front) $= 131° 43'$, $O : ii = 90° 7'$, $O : 2i = 135° 3'$, $O : 2\breve{2} = 141° 7'$, $O : 2i = 147° 39'$, $O : -2 = 130° 7'$.

Diallogite [p. 446].—A variety from Oberneisen, named *Himbeerspath* by Breithaupt, and occurring in acute rhombohedrons with truncated summits, afforded A. Birnbacher (Ann. Ch. u. Pharm. xcviii, 144): Carbonate of manganese 91·31, carbonate of lime 5·71, carbonate of iron 3·06.

Dolomite [p. 441, and Suppl. i, ii], near Lettowitz, etc., Moravia, E. F. Glocker, Jahrb. k. k. geol. Reichs., 1855, 98.

Dufrenoysite [p. 77, and Suppl. i, ii].—Ch. Heusser describes this species anew in Pogg. xcvii. 117. Forms: the dodecahedron (I); trapezohedron (2-2); cube with the angles replaced by 2-2; cube with planes, I, 2-2; cube with planes I, 2-2, $\frac{3}{2}$; cube with planes I, 2-2, 1 (octahedron), 6-6. Color on fresh fracture black, sometimes brownish or greenish; streak cherry-red. Hardness a little above that of fluor; brittle.

Epidote [p. 206, and Suppl. ii].—Occurs in beautiful crystals at Roseville, Byram Township, Sussex Co., New Jersey.—Kitchell's Geol. Rep., p. 171.

Epsomite [p. 384].—Occurs in Tennessee, at different places, and most remarkably at the Alum Cave in Sevier, in a mountainous region on the head waters of the West Fork of Little Pigeon river. Under the shelving rock, ("rock-house") masses of nearly pure epsom salt, almost a cubic foot in volume, have been obtained. *Safford's* Rep., p. 119.—Also found at many places in Spain especially in the province of Toledo, near Madrid.—Also formed at Vesuvius at the eruptions of 1850 and 1855. *Scacchi*, op. cit. p. 188.

ERUBESCITE [p. 38].—Analysis of ore from Coquimbo in Chili by W. Böcking (Ann. Ch. u. Pharm. xcvi, 244):—Sulphur 25·46, copper 60·80, iron 13·67=99·93.

FELDSPAR [p. 228, and Suppl. I, II].—Analyses (1 to 4) of Glassy Feldspars, by Dr. G. Lewinstein (Ueber die Zusamm. des Glas. Feldspaths, etc., Berlin, 1856). No. 1 from volcanic sand, 2, 3, 4, from trachyte and trachytic conglomerate:

	Si	Al	Fe	Ca	Mg	Na	K	
1. Rokeskill, Eifel,	66·65	18·91	—	1·49	0·76	4·45	7·74=100	G.=2·578
Oxygen,	35·28	8·83	—	0·42	0·31	1·15	1·31	
2. Perlenhardt,	[65·26]	17·62	0·91	1·05	0·88	2·49	11·79=100	
Oxygen,	33·94	8·23	0·30	0·29	0·35	0·64	1·96	
3. Drachenfels,	[65·59]	16·45	1·58	0·97	0·53	2·04	12·84=100	G.=2·60
Oxygen,	34·40	7·69	0·47	0·27	0·20	0·52	2·17	
4. Pappelsberg,	[66·03]	17·87	0·52	0·47	0·19	6·08	8·86=100	G.=2·616
Oxygen,	34·28	8·35	0·16	0·13	0·07	1·55	1·50	

In No. 3, the silica as directly determined equals 66·12.

The analyses give quite closely the orthoclase formula, $\dot{R}\,\ddot{S}i + \dot{R}\,\ddot{S}i^3$. If the iron be taken as *protoxyd*, the analyses correspond as well to the formula $9\dot{R}\,\ddot{S}i + 7\dot{R}\,\ddot{S}i^3$.

Ch. Heusser refers the *Hyalophan* of Waltershausen [Suppl. I], to Adularia (Pogg. xcvii, 128). It occurs in the dolomite of the Binnen valley, and agrees with that species in physical and crystallographic characters. The 2·28 p. c. of sulphuric acid found by von Waltershausen he attributes to mixture with pyrites, which is common in the rock in minute crystals. In seven different crystals examined with the blowpipe, he found no trace of sulphur. Moreover dolomite and heavy spar often occur as other impurities and partly may account for some of the results in the analysis.

The Weissigite of G. Jenzsch has afforded him (N. Jahrb. f. Min. etc. 1855, 800):

	Si	Al	Mg	Ca	K	Li	Fl, loss.
1.	65·00	19·54	1·61	0·19	12·69	0·56	0·35 =99·94
2.	65·21	19·71					0·55

The weissigite occurs in amygdaloidal cavities, in layers with chalcedony, etc. No. 1 is from the oldest or lowest of two layers, the color flesh red; G. = 2·551—2·553. No. 2 is from a second layer; color paler rose-red to reddish-white; G. = 2·533—2·553. The oxygen ratio for the protoxyds, peroxyds and silica in No. 1 is 3·15 : 9·13 : 33·75, which is near the orthoclase ratio. Part of the Weissigite No. 2 is pseudomorphous after Laumontite.

The analysis of No. 1 above comes nearest to the feldspar of Radeberg (see Suppl. II, under feldspar).

The same amygdaloidal cavities contain the chlorophanerite and the weissigite.

G. Bischof obtained (Lehrb. Geol. ii, 2171) from a feldspar pseudomorph after Laumontite from the Kilpatrick Hills (where others occur with the form of analcime also):

	Si	Al	Fe	Ca	Mg	K	Na	ign.
	62·00	20·00	0·64	0·60	*trace*	16·54	1·08	0·87= 101·72
Oxygen,	32·19	9·35	0·19	0·17		2·81	0·27	

FERGUSONITE.—See TYRITE, this Supplement.

FREISLEBENITE [p. 79].—A mineral which has been referred to Freislebenite and is probably near Bournonite, is described as new by Kenngott, in Pogg. xcviii, 165. Occurs in thin 4-sided tables (2 millimeters thick and about 12 across) of the monoclinic system, with two planes making up each margin of the table. Acute plane angle of base about 42°. H.=2·5. G.=6·06. Color iron black, streak black. Brittle. B.B. fuses easily to a black shining globule and yields finally a globule of silver. The silver constitutes about 30 per cent. The charcoal becomes covered with fumes of antimony and lead, and the mineral probably consists of silver, lead, antimony, and sulphur.

GALACTITE [Suppl. I, II].—In the author's 1st supplement (this Journal, May, 1855), he pointed out that the analysis of galactite by von Hauer gave the formula of natrolite, whence, he concluded, that galactite is probably *natrolite*. Authentic specimens of the mineral have since been examined by Dr. Heddle (Phil. Mag. [4], xi, 272), and the composition of natrolite obtained in each case. The following (1, 2, 3) are his results, together with analyses of related specimens:

	$\dot{S}i$	$\dot{A}l$	$\dot{C}a$	$\dot{N}a$	$\dot{H}$	
1. Glenfarg, white,	48·24	27·00	0·82	14·82	9·24	= 100 12
2. " red,	47·84	27·112	4·312	11·304	10·24	= 100 808
3. Campsie Hills,	47 324	27 36	2 63	13 354	10·392	= 101 060
4. Bishoptown, white,	47·60	26·60	0·16	15·86	9·56	= 99·78
5. " pink,	47·76	27·20	0·93	14·28	9 56	= 99·72
6. Bowling, near Kilpatrick,	48·033	25·261	2 313	13·975	9·723	$\dot{F}e$ 0 865, $\dot{M}g$ 0·403=100·573
7. Dumbarton Moor,	46·96	26·908	3·76	12·83	9·50	= 99 953

GALENA [p. 39, 506, and Suppl. I, II].—A galena containing 8·7 p. c. of sulphur, and also 51·30 of sulphate of lead has been observed at Neu-Sinka, Siebenburg, and described by R Hofmann. This mechanical mixture has been called *super-sulphuretted lead* and also *Johnstonite*. Jahrb. k. k. geol. Reichs., 1855, 1.

GARNET [p. 190, and Suppl. I, II].—An analysis of the green garnet which occurs in brevicite on the island of Stokoe in the Brevig Fiord afford Dr. D. Forbes (Edinb. N. Ph. J. [2], iii, Jan. 1856):

	$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$ & loss
1.	34 96	8·73	20·55	2·40	32·09	*trace*	1·27
2.	33 84	9 18	20·31		31·92	*trace*	——
3.				23 94	30·14		

The results correspond to the formula, as Dr. Forbes states, $(\frac{1}{3}\dot{C}a^3+\frac{1}{3}\dot{F}e)\ddot{S}i=\dot{C}a^3\ddot{S}i+\dot{F}e\ddot{S}i$=silica 35 61, lime 32·98, sesquioxyd of iron (alumina) 31·41=100, whence the mineral is identical in composition with melanite, notwithstanding its color. The crystals lie together, forming 6-sided prisms, or are distinct rhombic dodecahedrons. Color fine leek-green. G. (from 76 crystals at 60° F.) 3·64.

A Melanite from the Kaiserstuhl afforded Schill (G. Leonh. Min. Badens, 1855, in N. Jahrb. 1855, 838):

$\ddot{S}i$	$\dot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	
45·80	11·00	22·10	2·00	18·25	7·70	= 99·85

[In Suppl. II, under Garnet, for $\ddot{B}i$ read $\ddot{S}i$.]

GILBERTITE [p. 223].—E. Zschau states his opinion that Gilbertite at Graupen is derived from topaz, where it occurs associated with topaz, tin ore, fluor, apatite and quartz, in gneiss; and the same he regards as probably true of the gilbertite of Altenberg, Ehrenfriedersdorf, etc.—(Letter to G. J. B., as under URDITE.)

GLASERITE [p. 365].—According to Scacchi (op. cit., p. 186) this sulphate of potash, which is not common at Vesuvius, was rather abundant at the eruption of 1848, and occurred sparingly in that of 1855.

GUANO.—Prof. C. U. Shepard has given names to different portions of the hardened or "petrified" guano of Monk's Island, in the Caribbean Sea (Am. J. Sci., [2], xxii, 96) calling them collectively *pyroguanite* minerals. He remarks that the guano has "been subjected to the agency of heated trap rock, whereby the greater portion of it has been thoroughly fused." [The guano overlies and incrusts trap. But this appearance of fusion is merely a result of the consolidation and concretion through infiltrating waters. The same kind covers unhardened guano.—J. D. D.]

The tuberose and reniform massive guano material of a grayish white to brownish color, he has named *pyroclasite*, the name alluding to its flying to pieces when heated. H.=4. G.=2·36—2·4. "It consists of not far from 80 p. c. of phosphate of lime and 10 p. c. of water; while the remainder is made up of a little insoluble matter, carbonate of lime, sulphate of lime, sulphate of soda and traces of chlorid of sodium and fluorine." [The analyses by others give varying results.]

Another of the so-called species is named *Glaubapatite*. It is described as occurring in small tabular crystals, and in druses, forming botryoidal and stalactitic masses, with columnar radiating flattened fibres; also massive; color pale yellowish or greenish-brown; translucent; H.=3·5; G.=2·6. Also chocolate-brown to nearly black when massive. Chemical examination afforded, Phosphate of lime 74·00, sulphate of soda 15·10, water 10·30, organic matter, sulphate of lime and chlorid of sodium, *a trace* =99·40. [From the composition obtained, it can hardly be a chemical compound.]

Epiglaubite is the name of the third guano product. It occurs "in small aggregates or interlaced masses of minute semitransparent crystals of a shining vitreous lustre, which are always implanted upon druses of *glaubapatite*. H. about 2·5." It is stated to be "a largely hydrated phosphate, chiefly of lime, and may also contain magnesia and soda." Soluble in dilute muriatic acid. B.B. fuses easily to a semitransparent colorless glass tinging the flame green.

GYPSUM [p. 377, and Suppl. II].—Gray's Cave, Sumner Co., Tennessee, affords fine specimens of selenite, snowy gypsum, and "alabaster rosettes."—Safford's Rep., p. 119.

HARRISITE, *C. U. Shepard*.—A sulphuret of copper, like copper glance in composition but cubic in cleavage like the artificial sulphuret. Occurs in imperfectly formed cubes and octahedrons, and also disseminated in seams and massive. Color grayish-black. G.=5·4. Occurs at the Canton Mine, Georgia, with galena in quartz and also crystals of staurotide. A mass of 50 lbs. has been got out.—(Rep. on Canton Mine.)

HEDDLITE.—See under CONISTONITE.

HEMATITE or SPECULAR IRON [p. 113, and Suppl. II].—Scacchi has made observations on the hematite of the last eruption of Vesuvius (1855).—[Op. cit. p. 172]. He finds the hematite in crystals and also stalactites and incrustations on the scoria about the small cone. Among them are brilliant crystals, rhombohedrons, of 86° 51′, and double hexagonal pyramids having the faces inclined to a plane truncating the summit 141° 48′. There are also exceedingly thin scales or laminæ which are a lively blood red by transmitted light.

Besides these, there are octahedral crystals, some with their edges truncated, which are very brilliant, and according to exact measurement the octahedrons are regular or monometric. These octahedrons are intersected, often intricately so, by microscopic laminæ which cut through parallel to the octahedral faces, and these laminæ consist of hematite or specular iron, being crystalline plates flattened parallel to O ($0R$), and having on their edges faces of R and other planes of this species. These faces R are so exceedingly minute that M. Scacchi has not been able to ascertain any definite relation in position to those of the octahedron.

The specular iron of the lava, has often some magnetic qualities. A lamellar variety of the eruption of May, 1855, does not affect the magnetic needle, but manifests sensibly polar magnetism with the magnetoscope. Rhombohedral crystals with truncated summits, from the valley of Cancherone, and bipyramidal crystals from either Somma or Vesuvius (the locality being uncertain) are sensibly magnetic with the needle, and magnetipolar with the magnetoscope. A group of octahedral crystals from the same valley, united on a crust of hematite, is notably magnetic and magnetipolar. Octahedral crystals intersected by lamellæ of hematite are strongly magnetic and sensibly magnetipolar. The stalactites of hematite vary much in magnetic qualities.

Prof. Scacchi questions whether any of the crystals are pseudomorphs, and whether they are magnetite altered to hematite or hematite to magnetite. He says the first is not probable, as hematite is the usual product of sublimation about the volcano; and the second cannot be, as the crystals then should be all rhombohedral. Perhaps, he says, the sesquioxyd of iron is dimorphous: but on this point more evidence is required.

HITCHCOCKITE, *C. U. Shepard*.—No description given, except as follows (Rep. on Canton (Ga.) Mine, 1856)—a white earthy shell, sometimes no thicker than a mere varnish, on marcasite, at a mine affording galena, copper pyrites, blende, mispickel, automolite. "It is a hydrated phosphate of alumina with oxyd of zinc."

HORNBLENDE [p. 170, and Suppl. I, II].—Crystallographic and optical relations to pyroxene, *W. Haidinger*, Sitzungsb. Akad., Wien, xvii, 456.—An important paper.

LANTHANITE [p. 456, and Suppl. I].—Reported by Prof. C. U. Shepard as observed at the Canton Mine, Georgia (Rep. 1856), "at one spot in the 96 feet level, where it was found in very beautiful pink-colord crystals, lining small cavities of botryoidal white iron-pyrites."

LEAD [p. 17].—Native lead and lead ochre are reported as occurring at Zomelahuacan in the state of Vera Cruz, in a communication by M. Nöggerath (Zeits. d. geol. Ges., vi. 674). The locality is a valley over 3000 feet deep whose upper rocks are porphyry, melaphyre and basalt, trachyte, with metamorphic limestone and other beds below. The limestone in some parts still retains fossils, as *Ammonites Bucklandi* and *Ampullaria angulata*. The formation is 900 feet thick. The native lead and ochre occur in a white granular limestone. The lead ochre is somewhat foliated, of a wax or reddish yellow color to reddish where in contact with the native lead.

The amygdaloid from near Weissig, according to G. Jenzsch, sometimes contains in its cavities native lead, overlying pyrites, weissigite, chalcedony, quartz, galena, horn-stone, &c.—Jahrb. f. Min. 1855, 805.

Native lead is stated to occur also in the Altai (v. Hingenau's Oest. Zeits. 1854, in N. Jahrb. f. Min. etc. 1855, 837) seven miles from Mt. Alatau in the gold region. It is described as accompanying limonite, magnetite, and galena, in irregular masses a drachm in weight. Grains of native lead are also found with the gold near Ekatherinenburg in the Urals.

LEUCITE [p. 231].—The leucite of the modern lavas of Vesuvius, according to Deville (L'Institut, No. 1173), contains much more soda than that of the old lavas of Somma. The oxygen ratio for the soda and potash in the former is 1 : 2·09 for the crystals from the lava of 1855, and 1 : 8·21 for those from the old lavas of Somma (Fossa Grande). The same for the lavas of 1847, according to Damour, is 1 : 1·67.

Rammelsberg (Monatsb. Preuss. Akad. March, 1856, 148) has published a short paper on leucite and its pseudomorphs, remarking on the occurrence of a large proportion of soda in the altered leucite (2 of soda to 3 of potash).

LEUCOPYRITE [p. 61, 507].—Composition by G. A. Behncke (Pogg. xcviii, 187):

		S	As	Sb	Fe
1. Geyer,	G.=6·246—6·321,	6·07	58·94	1·37	32·92=99·30
2. Breitenbrunn,	G.=7·282—7·259,	1·10	69·85	1·05	27·41=99·41

Regarding the sulphur as being combined with part of the iron and arsenic as mispickel, the analyses, this excluded, become—the 1st, arsenic 67·06, iron 32·94=$Fe^2 As^2$; the 2nd, arsenic 72·19, iron 27·71=$Fe As^2$.

KEILHAUITE [p. 341, and Suppl. I].—D. Forbes and T. Dahll (Nyt. Mag. f. Nat. xiii,) mention the occurrence of masses of Keilhauite weighing 15 to 20 pounds, at Alve in Norway. H.=6·5. G.=3·72. Two perfect cleavages cross at 138°. Color dull brown. Streak pale dirty yellow. B.B infusible and unchanged. Specimen from near Narestö had G.=3·519; and a pale grayish brown, from Alve, G.=3·603.

In the Edinb. N. Ph. J., [2], iii, Jan. 1856, Dr. D. Forbes states that the percentage of titanic acid should read 28·04, instead of 28·84. A comparison of the angles of the crystals with those of sphene, made by Professor Miller of Cambridge, is here given.

KILLINITE [p. 170].—Analyses by Rev. J. A. Galbraith (J. Geol. Soc. Dublin, vi, 165):

	$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$	$\dot{N}a$	$\dot{H}$
1. Dalkey Quarry, Co. Dublin,	50·11	29·37	2·23	0·34	1·03	6·71	0·60	8·03=98·42
2. Kilimey,	50·45	30·13	3·53	——	1·09	4·81	0·95	7·53=98·54

The first gives the oxygen ration for $\dot{R}$, $\ddot{R}$, $\dot{S}i$ and $\dot{H}$. 1 : 5·97 : 11·53 : 3·10; and the second, 1 : 6·18 : 11·76 : 2·96; which Mr. Galbraith takes at 1 : 6 : 12 : 3, and writes the formula $\dot{R}\,\dot{S}i + \dot{A}l^2\dot{S}i^2 + 3\dot{H}$. The results agree very nearly with those of Lehunt and Blyth, and differ from the analysis of Mallet [see Min. p. 170]. Specific gravity

of No. 1, 2·678; of the same in fragments 2·688. Lithia was carefully looked for, and none found.

MAGNESITE [p. 441, 507, and Suppl. II].—Occurs in crystalline schist near Bruck in Styria, according to Fr. Foetterle (Jahrb. k. k. geol. Reichs., 1855, 68). Analysis afforded, $\dot{M}g\,\dot{C}$ 99·22, $\dot{F}e\,\dot{C}$ 0·69, $\dot{C}a\,\dot{C}$ *trace*, insoluble 0·09; another of the same, 94·77, 1·54, 0·86, 2·83. Specific gravity =3·033. H.=4·5. R : R=107° 16′.

MARCASITE [p. 60].—An analysis of a specimen from the Oxford clay near Hannover, afforded Dr. A. Vogel, Jr. (*N. Jahrb. f. Min. etc.*, 1855, 676), Sulphur 52·7, iron 46·9=99·6.

MISPICKEL [p. 62, 509, and Suppl. I, II].—Analyses by G. A. Behncke, in the laboratory of Prof. H. Rose (*Pogg.* xcviii, 184):

		As	Sb	S	Fe	
1. Sahla, Sweden,	G.=5·8205,	42·05	1·10	18·52	37·65	= 99·32
2. Altenberg, Silesia,	G.=6·042,	43·78	1·05	20·25	34·35	= 99·43
3. Freiberg, Saxony,	G.=6·046,	44·83	——	20·38	44·32	= 99·53
4. Landeshuth, Silesia,	G.=6·067—6·106,	44·02	0·92	19·77	34·83	= 99·54

Sb in 1, with trace of Bismuth; in 2, trace of copper; in 4, trace of copper and lead.

The first three analyses correspond closely to the received formula $Fe\,As^2+Fe\,S^2$. For No. 4, Mr. Behncke writes the formula $3Fe\,S^2+2Fe^2\,As^2$. But it has the same crystalline form as the true mispickel, and the peculiar composition may therefore be due to impurities.

An ore related to mispickel, from Zwiesel, having G.=6·21, afforded Dr. A. Vogel, Jr., on analysis (*N. Jahrb. f. Min. etc.* 1855, 674), Arsenic 54·70, sulphur 7·44, iron 35·20=97·34. This is near the result of Jordan's analysis of an ore from the mine Felicitas of Andreasberg, which gave, Arsenic 55·00, iron 36·43, sulphur 8·34=99·79. It gives the formula $Fe\,S+Fe^2\,As^2$, while that of ordinary mispickel is $Fe\,S^2+Fe\,As^2$, and therefore the author regards it as a distinct species.

NITRE [p. 433, and Suppl. I].—The nitre caves of Tennessee occur along the limestone slopes and in the gorges of the Cumberland table-land. A company is formed for working the nitrous earth in White County.—Safford's Rep., p. 117.

OPAL [p. 151].—According to E. F. Glocker, in Luckau, Moravia, a metamorphic limestone associated with gneiss contains a bed of brown hornstone and green opal (Jahrb. k. k. geol. Reichs., 1855, 98). The hornstone bed is 2 to 4 feet thick, and in some parts contains cavities with quartz crystals. The opal has a beautiful leek-green color, passing into yellow, brown and black, and occurs in a layer ½ to 2 inches thick. *Unghwarite* is sparingly associated with the opal; and occasionally pellucid hyalite is found in grouped concretions in a calc sinter.

OZOCERITE [p. 474, and Suppl. I].—In the Carpathian sandstone formation.—Glocker, Jahrb. k. k. geol. Reichs., 1855, 101.

PATERAITE.—A sulphuret of molybdenum containing 3 of sulphur to 1 of molybdenum ($Mo\,S^3$), has been thus named by Haidinger.—E. Zschau, in a letter to G. J. Brush.

PECTOLITE [p. 305, and Suppl. II].—Radiated crystallizations of pectolite occur in Ayrshire, having the columns 3 feet in length.—R. P. Greg, Jr.

PIAUZITE [p. 469].—According to Kenngott, occurs at Mount Chum near Tuffer in Styria; and near Tuffer, 3700 pounds (avoirdupois) have been obtained. It is a black resin much resembling a slaty and lamellar black coal.—Jahrb. k. k. geol. Reichsanst. 1855.

PICROMERID, *Scacchi.*—A sulphate of magnesia and copper, $(\dot{M}g.\,\dot{C}u)\,\ddot{S}+3\dot{H}$, obtained with the cyanochrome of Vesuvius from solution, and similar in form, the two being isomorphous, but color white. Angles: O or $O : ii$=75° 12′, $O : 1i$=154° 39′, $O : 2i$=116° 41′, $I : I$=109° 50′.—Op. cit., p. 191.

PINGUITE [p. 338].—At Sternberg in Moravia.—Glocker, Jahrb. k. k. geol. Reichs., 1855, 99.

PLATINUM [p. 12, and Suppl. I, II].—Composition of the platinum of Borneo, by MAX BÖCKING of Bonn (Ann. Ch. u. Pharm., xcvi, 243):—Platinum 82·60, iridium 0·66, osmium 0·30, gold 0·20, iron 10·67, copper 0·13, iridosmine 3·80=98·36. It occurs with grains of iridosmine, gold, chromic iron, magnetite. Among the platinum grains, there are some octahedrons of very regular form and also the cube.

PYROMELANE, *C. U. Shepard*, Am. J. Sci., [2], xxii, 96.—Found in grains or kernels among the sands at the gold washings of McDonald Co., N. C.; the grains irregular and pitted, looking somewhat like those of chondrodite. H.=6·5; G.=3·87; color reddish-brown to nearly black; translucent; lustre resinous to resino-vitreous.

Composition undetermined, no analyses being given. Said to be "essentially a titanate of alumina and iron, with only traces of glucina? and lime. It may also contain zirconia."

PYROSCLERITE [p. 291.]—The steatite-like mineral from Snarum occurring with the Völknerite, partly resembling a talc and partly a mica, which has been analysed by Hochstetter and Giratowski, is the subject of a note by Rammelsberg (Pogg. xcvii, 300), who has analysed a specimen named mica from the same place. The analyses give—

	$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}g$	$\dot{H}$	
1.	32·03	12·52	4·48	37·52	16·19 = 102·74,	*Hochstetter.*
2.	30·02	13·2	3·1	37·9	17·0 = 101·4,	*Giratowski.*
3.	34·88	12·48	5·81	34·02	13·68 = 100·87,	*Rammelsberg.*

The last (and the others nearly correspond) give the oxygen ratio for $\dot{R}$, $\ddot{R}$, $\dot{S}i$, $\dot{H}$, 13·37 : 7·57 : 18·12 : 12·16=2 : 1 : 3 : 2, and afford the formula $2\dot{M}g^3\,\dot{S}i+\dot{A}l\,\dot{S}i+6\dot{H}$, the formula deduced by Hartwell for the Kæmmererite of Bissersk. [The Voigtite, beyond, appears to be related to this compound.]

QUARTZ [p. 145, and Suppl. II.]—Capillary crystals, some an inch long, occur not far from Walchow, Moravia.—Glocker, Jahrb k. k. geol. Reichs., 1855, 100.

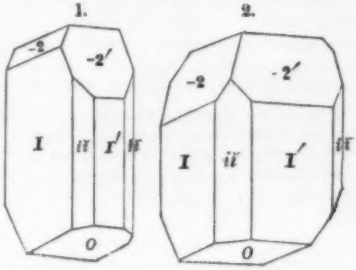
A singular compound structure in a crystal of quartz is described and figured by Kenngott (Pogg. xcvii, 628). A single hexagonal prism terminates in 6 prisms which coalesce across the centre so as to make a regular star of six rays.

QUICKSILVER [p. 14.]—Near Cividale, not far from Gagliano, in Venetian Lombardy, native quicksilver has been found in marl, connected with the "macigno," regarded as a part of the eocene nummulitic formation. Quicksilver in drift deposits has been found at Sulbeck near Luneburg, at Illye west of Deva in Transylvania, and at Montpelier. Near Eszbetek in Transylvania, and near Neumarkt in Galicia, springs issue from the Carpathian Sandstone, which are said sometimes to bear along globules of mercury, especially after thunder storms.—Jahrb. k. k. Geol. Reichsanst., Nov. 1855, in Quart. J. Geol. Soc. xii, Misc. 8.

RHODONITE [p. 167, and Suppl. II, Paisbergite.]—Under the name of Rhodonite, R. P. Greg, Esq., has described some brilliant crystals from the Paisberg iron mine near Phillipstadt in Sweden, which Dauber has referred to Paisbergite. Dauber's measurements are given in Suppl. II, under PAISBERGITE. Greg also makes the form triclinic, though near pyroxene. The planes *I* and *I'* (which are the analogues of the fundamental prism of pyroxene, see Suppl. II) give the angle 87° 20′; cleavage highly perfect parallel to *I*, less so parallel to *I'*; also highly perfect parallel to *O*.

Angles according to Greg, to which those obtained by Dauber and the corresponding angles of pyroxene are added:—

	GREG.	DAUBER.	In Pyroxene.
I : *I*	87° 20′	87° 38′	87° 5′
O : *I*	93° 50′	93° 28½′	100° 57′
O : *I'*	110° 40′	111° 8½′	100° 57′
I : *ii*	136° 20′	136° 8¼′	133° 32½′
I : *ii*	138° 20′	138° 11½′	136° 27½′
I : -2	148° 42′	148° 47′	144° 35′
I' : -2′	142° 30′	142° 39½′	144° 35′
I : -2′	86° 35′	85° 24′	



[Figure 1 is derived from Greg's figure. It represents the crystal flattened parallel to *I*. Figure 2 is the normal form of the crystals, and corresponds closely to Dauber's crystals as represented by him.

It remains to be ascertained whether there is any Rhodonite with a monoclinic form; in other words, whether Fowlerite or Paisbergite is not true Rhodonite.]

SAL-AMMONIAC [p. 92.]—Reported by Scacchi as formed at Vesuvius at the eruptions of 1855, but, as usual, where the lava has spread over soil with vegetation. It sometimes presented the form of the rhombic dodecahedron with cavernous faces: in 1850, it occurred in twins.

SALT [p 90, and Suppl. II.]—Announced by Scacchi as among the products of the Vesuvian eruption of 1855, (Op. cit., p. 183,) occurring at a small cone of eruption, in small cubes, incrustations, stalactites. Some *chlorid of potassium*, and also *sulphate of potassa* exists with the common salt in the stalactites. Scacchi also announces the probable occurrence of *chlorid of magnesium* in the saline crusts, together with the *chlorid of manganese*. The last was detected among the saline products of the eruption of 1855 (op. cit., p. 181.) It was detected in the crust by treating it with distilled water and testing with ferrocyanid of potassium, when the white precipitate thrown down acquired after a while a pale rose tint. Other trials also were made.

SERPENTINE [p. 282, 511 and Suppl. I, II.]—The Serpentine Rock of Roxbury and other places, Vermont, has been analyzed by A. A. Hayes (Proc. Bost. Soc N. H., Dec. 1855, and July 1856, and Am. J. Sci., xxi, 382), and shown to consist largely of carbonate of magnesia; the associated white spar is this species pure. He regards the rock as made up of this carbonate along with different silicates. An average of the rock of Roxbury afforded 38·00 of the carbonate and 62·00 of associated minerals. The rock of Proctorsville, Vt., gave 33·45 of $\dot{M}g\,\dot{C}$, leaving 66·55 for the rest, consisting of $\ddot{S}i$ 36·10, $\dot{M}g$ 18·70, Fe, Mn, O, 3·40, $\ddot{A}l$ 1·15, chromic iron 0·92, $\dot{H}$ 6·21=99·91. In another specimen of the same, the proportions of magnesite to the rest was 26·40 : 73·60.—The magnesite is attacked by muriatic acid with great difficulty.

The same serpentines had been previously examined by Dr. Jackson, who states and still holds (Proc. Bost. Soc. N. H., Feb. and July, 1856) that excluding the veins and some admixture of carbonate of magnesia, the serpentine has the usual composition, being a hydrous silicate of magnesia.

SILVER [p. 15].—A few filaments of native silver observed at a copper mine a mile from the Cheshire barytes mine, Ct.—S. Smith, in Proc. Amer. Assoc., ix, 188.

SMITHSONITE [p. 447, and Suppl. I.]—Pseudomorphs of Smithsonite having the form of dolomite, have been observed at the Lancaster zinc mines.—W. J. Taylor, Am. J. Sci., [2], xxi, 427.

SPHENE [p. 268].—A pulverulent decomposed sphene affording reactions for water (12·5 per cent) and titanic acid, has been named *Xanthitane* by C. U. Shepard (Am. J. Sci. [2], xxii, 96). The color pale yellowish white; lustre feeble; brittle; hardness = 3·5; G = 2·7—3·0. No analysis has been made. Found in a decomposing feldspar, associated with zircon, at Green river, Henderson Co., N. C.

STANNITE [p. 512.]—Analysis by Bischof (Chem. u. phys. Geol., ii, 2026).

$\ddot{S}i$	$\ddot{S}n$	$\ddot{A}l$	$\dot{F}e$	$\dot{C}a$	ign.
51·57	38·91	4·53	3·55	0·16	0·43 = 99·15

It appears hence to be a mixture of different substances. It is probably a pseudomorph after feldspar, in which tin ore has replaced much of the original ingredients. It occurs massive, with a small conchoidal fracture.

STAUROTIDE [p. 261].—Found at the Lead mine, Canton, Georgia, in the quartz or quartzose mica slate which is the gangue of the vein, sometimes penetrating the pyrites and copper ore. The crystals are "rarely thicker than a large-sized needle." Prof. Shepard says that they appear to be identical with the Partschin of Haidinger, (see Suppl. I) [but partschin is a very different mineral from staurotide, having the garnet oxygen ratio.]

STIBNITE or Stibine (Antimony Glance) [p. 33].—Occurs in Katharinenburg in the Urals. Kokscharov, Min. Russl. ii, 163.

STILBITE [p. 332].—A mineral related to Stilbite has been described by J. W. Mallet (this Journ. xxii, 179). Coarse granular massive, grains cleavable, pearly on two opposite faces, monoclinic?, hardness a little above that of calcite, G.=2·252. With strong muriatic acid yields a jelly. Composition—

$\ddot{S}i$	$\dot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$, little $\dot{N}a$	$\dot{H}$
53·95	20·13	12·86	*trace*	0·87	12·42=100·23

corresponding nearly to $\dot{C}a\,\ddot{S}i + \dot{A}l\,\ddot{S}i^3 + 3\frac{1}{2}\dot{H}$.—From the Isle of Skye, Scotland.

STILPNOMELANE [p. 287].—Observed by E. F. Glocker, in Moravia and Eastern Silesia, at Seitendorf near Troppau, Bärn, two miles from Sternberg in Moravia, at Sternberg, and at Liskowitz and Wächtersdorf, and Jessenetz. The rock containing it is clay slate or argillite, probably of Devonian age. It is often associated with chlorite, calcite, and magnetite, and sometimes with pyrites and limonite. Chlorite especially is its common attendant, and the two have close resemblances, so that when mixed they are distinguished with some difficulty.

TANTALITE [p. 351].—Tantalite from Chanteloube in Limoges, has given Dr. G. Jenzsch the following composition (Pogg. xcvii, 104):

	$\ddot{T}a$	$\ddot{Z}r$	$\ddot{S}n$	$\dot{F}e$	$\dot{M}n$		
1.	83·55	1·54	1·02	14·48	*tr.*	=100·59	G.=7·703
2.	78·98	5·72	2·36	$\ddot{F}e$ 13·62	*tr.*	=100·68	G.=7·027–7·042

The second analysis is of specimens partially altered by exposure. The fresh pieces have a conchoidal fracture, submetallic adamantine lustre. H.=6·5, streak iron-black to blackish-brown. The specimens analyzed had been received by H. Rose from M. Damour.

THENARDITE [p. 365].—Scacchi has described (loc. cit.) an anhydrous sulphate of soda under the name of *pyrotechnite*, (alluding to its volcanic origin) found on the scoria of the eruption at Vesuvius of 1855. On being dissolved and evaporated, octahedral trimetric crystals were obtained. Calling the planes of the octahedron 1, the planes are *I*, 1ī, 1, 3$\breve{3}$; and the angles $I : I$=118° 37′, 1ī : 1ī (over base) 128° 58′, 1 : 1, basal.=135° 21′, pyramidal 123° 39′ and 74° 36′, 3$\breve{3}$: 3$\breve{3}$ basal.=153° 41′, pyramidal 63° 48′ and 123° 2′. [The planes and angles are those of Thenardite, a described octahedron of which has the angles, 135° 41, 123° 43′ and 74° 18′. See Brooke and Miller's Min., p. 534. The angles in the author's Min., are from Hausmann.—J. D. D.]

TRITOMITE [p. 311].—According to Dr. D. Forbes, the crystallization of tritomite is doubtful (Edinb. N. Ph. J., [2], iii, Jan. 1856). G.=3·908. Composition according to his analysis:

$\ddot{S}i$	$\dddot{W}$ (with $\ddot{S}n$)	$\dot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{Y}$	$\dot{L}a$	$\dot{C}e$	$\dot{F}e$	$\dot{M}n$	$\dot{H}$
21·16	3·95	2·86	4·04	0·09	0·33	4·64	12·41	37·64	2·68	1·10	8·68=99·58

Dr. Forbes states that the received formula $\dot{R}\,\ddot{S}i + 2\dot{H}$ is probably as correct as any other which can at present be proposed.

TSCHEFFKINITE [p. 341].—Description by Kokscharov in Min. Russl. ii, 150. He states that he knows of five specimens of the mineral, and that most of the so-called Tscheffkinite is Ural-orthite.

TYRITE [Suppl. i].—This species, described by D. Forbes, is referred to Fergusonite by A. Kenngott (Pogg. xcvii, 622). His specimens were received from Dr. Rondi of Dresden, who suggested on sending them a possible relation to that species. They were from Helle and Tromsöe near Arendal. One of them is a portion of a crystal sufficient to establish its hemihedral dimetric character and a correspondence in the occurring planes, these planes being *O*, 1, 3$\frac{3}{2}$ [figure in Min., p. 350], and giving, as nearly as can be determined, the same angles. Haidinger describes Fergusonite as

having traces of a basal cleavage. These crystals show no distinct traces. Color brownish-black. Lustre between submetallic and waxy. Thin splinters a yellowish brown translucence on the edge. Streak pale grayish brown. H.=6·0. G=5·555; another piece 5·100, which is below that of fergusonite for which Allan obtained 5·838, and Turner 5·800. The tyrite strongly decrepitates before the blowpipe while the fergusonite only very slightly so.

The evidence from form and most of the physical characters is so strong that we can hardly doubt the identity.

URDITE, *D. Forbes* and *T. Dahll* (Nyt. Mag. f. Nat. xiii).—Occurs in granite near Nöterö in Norway. Crystals clinohedral. Color yellowish-brown to brown; streak pale grayish-yellow. Lustre greasy. Subtranslucent. G. of a fragment of a crystal 5·204, 5·19, 5·26. In a tube no water. BB. infusible, but glows and color becomes darker on cooling; with borax in the reducing flame, a glass which is yellow, somewhat greenish while hot, and colorless on cooling; with salt of phosphorus, a skeleton of silica. No reaction of titanium or manganese. On charcoal affords a white metal (tin!). Powder not attacked by hot muriatic acid.

According to E. Zschau, (letter addressed to G. J. Brush, dated Dresden, March 9, 1856,) the *Urdite* has the form of monazite, and is that species; he states that he has recognized the planes of Monazite, *I*, *ii*, $-1i$, -1, *O*, $2i$, and $\breve{2}\breve{2}$ [see Min., p. 402.] The crystal is about an inch in length and breadth, and half an inch in thickness; its weight 20·5 grammes. It occurs in feldspar (in granite intersecting gneiss), and also enveloped in orthite.

VANADINITE [p. 362, and Suppl. n].—According to Rammelsberg, (Monatsb. Preuss. Akad., March 1856, 153), the Vanadinite of Mt. Obir near Windisch-Kappel in Carinthia, affords for the angle of pyramid (1 : 1 over terminal edge) 142° 30′. The same angle in mimetene, according to G. Rose, is 142° 7′; in pyromorphite, 142° 15′; in apatite, 142° 20′. Hence phosphoric and vanadic acids appear to be isomorphous.

VIVIANITE [p. 415].—Analyses of earthy vivianite (Eisenlasur), by H. Struve (Bull. St. Petersb., Class. Phys.-math., xiv, 171–173):

$\dot{P}$	$\dot{F}e$	$\dot{F}e$	$\dot{H}$	
29·17	21·34	21·54	27·50	= 99·55
19·79	33 11	13·75	26 10,	$\dot{M}g$ 7·37 = 100·12

Found in crystals, perfectly colorless when first obtained, in the greensand, near Middletown, Newcastle Co., Delaware.—Prof. J. C. Booth in lit.

Observed in human bones.—Nicklès, Am. J. Sci., [2], xxi, 402.

VOIGTITE.—This new mineral, described by E. E. Schmid (Pogg. xcvii, 108), is from Ehrenberg, near Ilmenau. It resembles a mica, and is disseminated in granite, replacing true mica. The granite is partly graphic granite. In oblong scales, seldom over 1 millimeter thick, micaceous in structure; color leek green, and thin scales translucent, though often yellowish or brown and opaque from alteration; lustre pearly; hardness somewhat above 2; sp. gr. 2·91. In a glass tube yields water, exfoliates, and becomes dark brown and metallic in lustre. BB. fuses easily to a black glass; and gives the reaction of iron. Attacked by cold muriatic acid, giving a yellow solution, and the insoluble part becomes after a few days colorless. Composition:

$\breve{S}i$	$\breve{A}l$	$\dot{F}e$	$\dot{F}e$	$\dot{M}g$	$\dot{C}a$	$\dot{N}a$	$\dot{H}$
33·83	13·40	8·42	23·01	7·54	2·04	0·96	9·87=99·07

giving the formula $\dot{R}^2\breve{S}i + \ddot{R}\breve{S}i + 3\dot{H}$, which is that of Biotite, excepting the water.

The name *Voigtite* is in honor of M. Voigt, director of the mines of Saxe Weimar.

[A mineral of the same composition essentially, from Pressburg, Hungary, has been analyzed by von Hauer. See Wien. Sitzb., xi, 609, 1853, and author's Min., p. 295.]

VÖLKNERITE [p. 134].—Analyses by Rammelsberg of the mineral from Snarum, called also Hydrotalcite (Pogg. xcvii, 296):

	$\dot{C}$	$\ddot{A}l$	$\dot{M}g$	$\dot{H}$	
1.	2·61	37·27	19·25	41·59	= 100·72
2.	6·05	38·18	17·78	[37·99]	= 100·00
3.	7·32	37·30	18·09	[37·38]	= 100·00
4.	7·30	37·04	18·87	37·38	= 100·59

The mineral was in bent or curving lamellæ, which break into fibres. G.=2·091. Rammelsberg regards the carbonic acid as introduced subsequent to the formation of the mineral, and obtains the formula, $\dot{M}g\ \ddot{A}l+4\dot{M}g\ \dot{H}^3$=alumina 19·80, magnesia 38·56, water 41·64=100; or perhaps, $\ddot{A}l\ \dot{H}^3+5\dot{M}g\ \dot{H}^2$=alumina 19·14, magnesia 37·27, water 43·59=100.

WITTICHITE (Kupferwismutherz) [p. 88, and Suppl. I].—Analysis by E. Tobler (Ann. Ch. u. Pharm., xcvi, 207).—(1) part soluble in muriatic acid; (2) part insoluble, ibid.; (3) the whole together:

	S	Bi	Cu	Fe	
1. Soluble part,	16·00	49·12	30·70	1·64	= 97·46
2. Insoluble part,	1·26	0·53	0·86	1·27	= 3·96
3. Whole,	17·26	49·65	31·56	2·91	=101·38

The results agree nearly with those of M. Schneider. The formula may be $2\dot{C}u\ S+Bi^2\ S^3$; but the sulphur is not sufficient for it. It corresponds better with the analyses to write it, $2\dot{C}u\ S+Bi^2\ S^3$, or $\dot{C}u\ S+Bi\ S$; the iron being included with the $\dot{C}u$.

The composition of this ore from Wittichen is discussed by R. Schneider, in Pogg. Ann., xcvii, 476.

WOLFRAM [p. 351, and Suppl. I, II].—An imperfect crystal of wolfram from the west shore of "Chief's Island," Lake Couchiching, Canada West, has been described by E. J. Chapman (Canadian Jour. [2], i, 308). It was found there in a boulder consisting of gneiss traversed by a vein of coarse granite, containing red orthoclase and some magnetite.

XENOTIME [p. 401, and Suppl. I, II].—E. Zschau has described the associations of Xenotime in the granite of Hitteröe, Norway, in the Neues Jahrb. f. Min. etc., 1855, 513. The minerals occurring with it are allanite, malacone (related to zircon), polycrase, titanic iron; and very rarely gadolinite. The crystals of xenotime sometimes form regular twins with malacone (this Journ., xx, 273), and also have a regularity of somposition with some crystals of orthite (allanite), titanic iron and polycrase. For details, we refer to the paper.

Analysis of the xenotime afforded, $\dot{P}$ 30·74, Yttria 60·25, $\dot{C}e$ 7·98, $\ddot{S}i$, Fe, *trace.*

ZINCITE [p. 110, and Suppl. II].—Occurs at Schneeberg as a pseudomorph after Blende.—Hartm. Berg. u. Hutt. 1853, in N. Jahrb., 1855, 841.

Additional references.

American localities.—At Canton Mine, Ga., according to Prof. C. U. Shepard (Rep. 1856), chalcopyrite, harrisite, erubescite, hitchcockite, melaconite, galena (containing 30 to 56 oz. silver to the ton), pyromorphite, plumbo-resinite "in thin seams and varnish-like coatings," pyrites, marcasite, mispickel, blende, native copper, automolite, staurotide, kyanite, ilmenite.

Minerals accompanying the Gold of Australia. Quart. J. Geol. Soc., 1854, x, 303.

On the minerals and pseudomorphs of Przibram, by E. Kleszczynski, Jahrb. k. k. geol. Reichs., 1855, 46.

ART. XXIII.—*Correspondence of M. Jerome Nicklès, dated Paris, July*, 1856.

Academy of Sciences.—Death of M. Binet.—The Academy of Sciences has just lost its President for the year 1856—the geometer M. Binet, the pupil, associate, and friend of Laplace, and better acquainted with his ideas and works than any of his cotemporaries. He took an active part in the publication of the Mécanique Céleste, and wrote several memoirs on this subject which will always be consulted with profit. Besides this, he is the author of the Treatise on Eulerian Integrals, and had an intimate knowledge of the works of very many geometers both ancient and modern—knowledge which was always at the service of others, but now is lost to the world. From 1816 to 1830 he was Director of the Polytechnic School, when he was replaced by the distinguished physicist Dulong. He entered the Institute in 1843. He died on the 12th of May last at an advanced age.

Agricultural Universal Exhibition.—It is ten years since this kind of exhibition or fair began, and extended to the different regions of France; and now since the idea of Universal Exhibitions has been introduced, the Agricultural fairs are taking a more liberal range. This exhibition was not as well attended as was hoped, and France was but moderately represented, there being hardly 150 French contributors. The animals admitted were cattle, sheep etc., pigs, and fowls. There was also a horticultural exhibition of unusual beauty, where the Azaleas were combined in great perfection of taste, with Rhododendrons and Calceolarias. The ornamental trees were inferior to those of the Horticultural exhibition of last year.

The department of Pisciculture was a new and interesting feature in this exhibition. There were several basins or reservoirs where the apparatus of Pisciculture of the Collège de France and the products of the establishment founded at Huningue (Haut-Rhin), were exhibited:—including salmon from the Danube and Rhine, the French salmon, trout, etc. etc., comprising various species which have been acclimated without difficulty. Two years since the experiment was begun towards stocking the artificial lake which the city of Paris has made in the Bois de Boulogne, which is supplied with water by means of a great steam engine; this lake, which has no communication with other waters, is now filled with trout and salmon of the finest kinds.

Another department, adding to the interest of the exhibition, was that of Apiculture—or bees, and the manner of raising and treating them. A part of the exhibition was the same as that in the great Crystal Palace Exhibition.

Fecula of the Horse-chestnut.—Among the products in the Agricultural Exhibition, the different kinds of fecula were of prominent interest, and especially the fecula of the horse-chestnut (*Æsculus hippocastanum*). The exhibitor of it, M. Callias, has been honored with the silver medal, because of the simple and economical method of extraction which he has brought into use, permitting the fecula to be sold 25 to 30 per cent less than other related products.

This fecula has been many times commended to attention since Bachelier in 1615 brought the tree from Constantinople, (it coming originally from Southern Asia). Parmentier, Baumé and others sought successively to bring it into general use. But the mode of manufacture was not satisfactory, partly because of the presence of a resinous substance which was separated with difficulty, and partly on account of the dark shell of the nut, which it was thought necessary to remove before extracting the fecula.

In the new process, the nuts are grated with the bark on, and treated like the potato with its skin; the material is then washed in water as easily and as economically as the potato, so that the price is not above 20 centimes per kilogram, the cost of cultivation and manufacture being included. 20,000 kilograms of the fecula manufactured this year with the apparatus that is used for the potato have settled the question of its importance.

Astronomy.—Among the changes at the Observatory at Paris, the establishment of the "Annals of the Observatory" is worthy of mention. The object of this periodical is to publish the results of observations of every kind connected with the Observatory, and also of such tables and reductions as are indispensable to give the results an actual scientific value. The completion of the tables to facilitate the discussion of the observations and aid in comparing with theory is making rapid progress. The first volume of the publication is just from the press. It contains the Report of M. Leverrier addressed to the French Government, and following this, a statement of the system of organization now established. There are next, astronomical researches of various kinds, with the principal formulas for the calculation of functions.

This work, whose numerous mathematical formulas render it of difficult execution, goes out almost without a fault from the ably conducted press of Mallet-Bachelier.

View of a part of the surface of the Moon.—M. Secchi, Astronomer at Rome, has sent to the Academy a photographic view of the part of the moon's surface in which stands the crater named *Copernicus*. The scale is about $\frac{1}{663.000}$. The photograph was not taken direct from the moon, but from a design executed with great care on a somewhat larger scale, and having for its base a micrometric triangulation of the principal points of the area. The details were brought out with a lens magnifying 760 to 1000 times: the work, seemingly easy, was attended with great difficulties, on account of the change in the shadows with every hour, the moon's libration and change of distance. To avoid all these difficulties a general sketch was first made under the most favorable light and view for marking out the crater, such as is ordinarily had when the moon is ten days old. After this, the details were separately made out, and then all were combined in their true relations, so as to make the complete sketch. The result thus reached was corrected by several examinations made from the first point of view. A professed draughtsman was occupied with the work during seven consecutive lunations, without counting the time employed previously in practicing preparatory to the work.

As the drawing was intended to represent the great central crater, the area around is not yet filled with all the details that may be introdnced.

After completing the design with every possible care, M. Secchi has had copies taken by photography, one of which he has sent to the Academy. The crater or annular mountain has two circuit walls. The outer, which is the lowest, has a diameter of about 48 seconds (one second corresponds to 1·820 meters); the inner, the true border of the crater, has a mean diameter of 38 seconds, and has a peak, somewhat elevated, on its western side. The inner area is 20 seconds across. The interior has a steep escarpment around, and a triple circuit of broken rocks and a great number of large masses piled up at the foot of the escarpment, as if they had fallen from above. There are two great depressions in the north and south borders of the crater; and it is remarkable that in the direction of this line, outside, both north and south, there are some small craters.

After having established the perfect resemblance which exists between the volcanic mountains of the environs of Rome and the lunar mountains,* (comparing with the chart of the Roman territory made by the French officers), M. Secchi adds, "The question whether volcanic action in the moon is actually extinct, can be answered only after there shall have been made a map of the moon's surface for a given period with the utmost accuracy and on a large scale." It is to help onward this project, that he has undertaken the work above described.

Meteorological System of France.—Notwithstanding the enemies of meteorological observations alluded to in a former communication, the system for France is now nearly established. The telegraph reports to the director of the Paris Observatory, M. Leverrier, the observations made at different points over the empire. All the stations are supplied with instruments which have been compared with great care. The instrument which has undergone the most modification is the barometer. The barometer of Fortin, which is the most perfect of all, has not been adopted, because it works well only in the most experienced hands, and the determination of the atmospheric pressure with it is an experiment in physics of great delicacy rather than a direct observation. The instrument used is very simple and gives the pressure of the air at a single reading, the corrections being contained in tables.

Besides the corps of amateur meteorologists, a regular system of observers under administrative direction was required, which should be perpetual and independent of the direct action of those constituting it. This is now realized, the stations being established within the telegraphic bureaus, the assistants in which have had a good education. The number of stations is now 25, and they are situated in the principal basins of France. Each person in charge of a station is required to make three observations a day, but may make more at his pleasure. These observations are registered in a book kept at the station; and at 7 or 8 o'clock in the morning they are reported by the telegraph according to a concerted formula, to the Paris Observatory, where they are recorded on special registers, to be tabulated and published.

* The more thoroughly the volcanic mountains of the moon are studied, the more completely do they sustain the resemblance to the great boiling lava craters like Kilauea of the Hawaian Islands, as pointed out by the writer in an article on the Volcanoes of the Moon, in this Journal, volume ii, 2nd Series, page 335, 1846.—J. D. D.

This system has already worked for a month with entire regularity; and when it shall have been firmly established and have received the sanction of time, M. Leverrier will undertake to extend the system to the neighboring countries. The concurrence of Belgium is promised, and we hope for that of England. Indeed, according to a recent statement at the Observatory, the brother of the Austrian emperor and the Royal Prince of Sweden have promised to contribute all in their power to promote the extension both of the political union and meteorological union of France to Austria and Sweden. But it is well known what such promises are worth.

Inundations.—Since the calamity from floods which has befallen a part of France, many notes and memoirs have been published, both with reference to preventing such catastrophes in the future, and the discovery of the cause. On the latter point there are two opinions, some attributing the rain to hot vapors brought with the winds of Africa, others to the Gulf stream descending very low in the ocean at this time and saturating the air with moisture. Both theories consider the winds as carried against the Alps, there to precipitate their moisture in the state of rain; and it is in accordance with this view that the part of Germany beyond the Alps to the south and east has suffered from drought.

To these meteorological causes, supposing one or both real, we may add the clearing away of forests, the opening of canals, and the means used to facilitate the flow of waters, whence, a drop of water makes a quicker passage to the rivers and thence to the sea, than in the ancient times of uncultivated France. The rivers consequently enlarge suddenly beyond measure and commit ravages from which France periodically suffers. It seems the duty of science then to combat the evils due partly to the progress of science. The organization of a system of meteorological observations is one step towards this end. The inspection of the pluviometer may enable us to foresee by several days the increase of a river, like that at Lyons; and if placed about the heights, the telegraph may announce six days in advance, a flood on the Saone, and enable the people to put the rivers in a state to carry off the excess of water and prevent much of the evil. MM. Pouillet, Regnault and others will hardly deny after this the utility of meteorological observations.

Electricity.—Substitute for the copper wire in the construction of Helices.—The cost of helices of fine wire, and the limit of thickness to which the fine wire can be covered with silk for insulation, are two impediments which M. Bonelli has sought to set aside by very simple means. He takes a band of paper of the height of the helix of an electro-magnet, or of the corresponding part of a galvanometer; this band carries parallel to its edge, metallic lines $a\ a'$, $b\ b'$, etc., passing from one extremity to the other; these lines, placed in the circuit, will give passage to the current, while they are also insulated from one another by the paper which separates them; so that the current will pass uninterruptedly provided the lines of metal are unbroken. The number of these lines which may be put on a band of paper is almost indefinite. Leaving their extremities free, the current may be made to pass, either along the lines united, or in all of them at the same time and in the same direction.

Effects with Ruhmkorff's Apparatus of Induction.—M. Léon Foucault has been engaged for some time in studying the effects of the apparatus of Ruhmkorff. In place of using only a single apparatus, he operates with four, which are united so as to work together by means of a peculiar interruptor,—a mercury interruptor. In the open air, four machines of ordinary dimensions, under the action of ten couples of a Bunsen's large battery, give a spark at a distance of seven centimeters (nearly three inches).

The addition of a condenser in which the armature acts on a surface of 30 to 50 centimeters, renders the spark very bright, and reduces the explosive distance to 18 millimeters. The series of discharges, which follow one another with rapidity, give to the point where the operation is going on, a light like that of an ordinary lamp. Although the brightness from such a source does not appear excessive, it acts on the organs of sight, when observed directly, like the light from the carbon of the galvanic circuit, producing a painful sensation which may continue for hours afterward. The interposition of glass of uranium prevents or diminishes very much this effect, which appears to show that it is due to the very refrangible and in part invisible rays which constitute in large proportion the electric light.

The discharge of the four instruments traverses easily a tube exhausted by an air pump two metres long; a column of light is developed from one end to the other and presents throughout its extent a kind of stratification, such as has been noticed in the interior of the electric egg.

Electric Chronometers.—The ingenious artist, M. Bréguet, son of the skillful mechanician who invented the Bréguet Thermometer, etc., has devoted himself to the construction of chronometers in connection with the Electric Telegraph. During his recent stay at Paris, he has placed a chronometer of great simplicity in a gas lamp. It consists of a dial armed with two needles moved by electricity, which mark the hours and minutes. The whole mechanism consists of three wheels, a pinion, an escapement, and a double rachet, with a means of reversing the current: two wires pass from the lamp to a regulating clock situated in the apartment of M. Bréguet. This inventor proposes to divide Paris into 12 electric districts, and place in each mayoralty a regulator which shall distribute time throughout the district both to the public lamps and private houses.

Gas and Steam Manometer Alarm.—The same artist has made another application of electricity. He has constructed an apparatus for informing the engineer either of gas or steam apparatus, by the stroke of a bell, that the pressure is above or below what is required. It is accomplished in a very simple manner. At the extremities of the arc which the needle of the manometer passes over, there are put two metallic points which limit its movement in either direction; the contact of the needle with these metallic points is made to close a circuit proceeding from a small battery, and this puts the bell in play.

On a Cause of Atmospheric Electricity.—There exists between the living plant and the soil supporting it an electric current, which always moves in the same direction, that is, the soil is constantly positive, the plant continually negative. This fact, was first observed by M. Becquerel, Sr., and for several years it has been pointed out by him as one of the

causes of atmospheric electricity. On repeating the experiments a year since, he was struck with the anomalies presented in operating on the bank of a stream, in the water, and also at a certain distance from the plant, and was thus led to study the effects under these circumstances. These effects are complex and change their direction and intensity with the chemical composition of the water and the soil. In each case the results depend on heterogeneity between the water and the soil; alkaline waters are negative, and acid waters positive; it follows therefore, that sometimes the effects are null, as happens on the waters of a river and along the sandy banks washed by the floods.

Bibliography.—Annales de l'Observatoire de Paris publiées, par U. J. LE VERRIER. Vol. I, in large 4to, of 420 pages, with a plate. Paris; Mallet-Bachelier. Price 28 francs.—We have remarked on this work under the head of *Astronomy.*

Œuvres de FR. ARAGO.—*Notices Scientifiques.* Vol. II. Paris: Gide et Baudry.—This volume contains, 1st, A historical notice of the Steam Engine; 2d, a Report on Railroads, historical in character, made to the Chamber of Deputies, June 12, 1836; 3d, A Report on the introduction of the Electric Telegraph into France, a report combatted at the time by "les obscurantistes" on the ground that the electric telegraph was a chimera; 4th, a Report on limestone, mortars, hydraulic cements, native and artificial puzzolanas; 5th, A series of remarkable articles under the title of Navigation, treating of different maritime questions. An announcement of the subjects in this volume is sufficient to exhibit its importance.

Le Materiel Agricole, ou Description et Examen des Instruments et des Machines usités en Agriculture, par A. JOURDIER.—Paris: Hachette. 1 volume in 12 mo, containing in a concise and elegant form accounts of the principal agricultural operations followed in France.

Notions d'Hygiène pratique, par le Dr. ISIDORE BOURDON.—1 volume in 16 mo. of 380 pages, treating fully of the general subject of Hygiene.

Theorie de Logarithmes par TARNIER, Doctor ès Sciences mathematiques.—A pamphlet of 92 pages in 8vo. *Paris:* Hachette.

Elements de Geographie, par CORTAMBERT. 1 volume in 8vo. *Paris:* Hachette.—The author is a Professor of Geography of high reputation with the Parisian public, and his works are in good demand.

Precis d'Histoire Naturelle, par M. DELAFOSSE. 7th edition in 1 volume of 688 pages 12 mo.—This book is in the hands of all the students and is a convenient introduction to the natural sciences. Its author, M. Delafosse, is moreover Professor of Mineralogy in the Faculty of Sciences of Paris, where he has given instruction for nearly twenty years.

Les applications nouvelles de la Science à l'Industrie et aux Arts, en 1855, *par* L. FIGUIER, M.D., Doctor ès Science, Redacteur du Bulletin Scientifique de la presse. 1 volume of 788 pages in 12 mo.—This small volume is one of the results of the "Universal Exposition" at Paris. It has been well prepared, and has in view an exhibition of the principal applications of science relating to the Steam engine, Steam vessels, Electromotors, Clocks, Electricity and Railroads, Photography, Photographic engraving, Galvanoplasty, Stearic candles, Electric illumination, Heating by gas, Aluminium, etc. etc.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Some Experiments in Electro-physiology;* by Prof. MATTEUCCI, in a letter to Dr Faraday, dated May 1, 1856, (Phil. Mag. [4], xi, 461.)—I think I have already told you that for some time past I have been making experiments in electro-physiology. Allow me now to communicate to you the results of my work.

I have lately succeeded in demonstrating and measuring the phenomenon which I have called *muscular respiration.* This respiration, which consists in the absorption of oxygen and the exhalation of carbonic acid and azote by living muscles, and of which I have determined the principal conditions and intensity compared with that of the general respiration of an animal, has been studied particularly on muscles in contraction. I have proved that this respiration *increases considerably* in the act of contraction, and have measured this increase.

A muscle which contracts, absorbs, while in contraction, a much greater quantity of oxygen, and exhales a much greater quantity of carbonic acid and azote, than does the same muscle in a state of repose. A part of the carbonic acid exhales in the air, the muscle imbibes the other part, which puts a stop to successive respiration and produces *asphyxy of the muscle.* Thus a muscle soon ceases to contract under the influence of an electro-magnetic machine when it is enclosed in a small space of air; this cessation takes place after a longer interval of time if the muscle is in the open air, and much more slowly still if there be a solution of potash at the bottom of the recipient in which the muscle is suspended. Muscles which have been kept long in vacuum or in hydrogen are nevertheless capable, though in a less degree, of exhaling carbonic acid while in contraction; this proves clearly that the oxygen which furnishes the carbonic acid exists in the muscle in a state of combination. According to the theories of Joule, Thomson, &c., the chemical action which is transformed, or which gives rise to heat, is also represented by a certain quantity of *vis viva*, or by an equivalent of mechanical work. I have therefore been able to measure the *theoretical work* due to the oxygen consumed, taking the numbers which I had found for muscular respiration during contraction, and in consequence the quantity of heat developed by this chemical action, and finally this *theoretical work* according to the dynamical equivalent of heat. I have compared this number with that which expresses the *real work* which is obtained by measuring the weight which a muscle in contraction can raise to a certain height, and the number of contractions which a muscle can perform in a given time. It results from this comparison, that the first number is somewhat greater than the second, and the heat developed by contraction ought to be admitted among the causes of this slight difference: these two numbers are therefore sufficiently in accordance with each other.

I have completed these researches by some new studies on *induced contraction*, that is to say, on the phenomenon of the irritation of a nerve in contact with a muscle in contraction. A great number of experiments lately

made on the discharge of the torpedo, and on the analogy between this discharge and muscular contraction, have led me to establish the existence of an electrical discharge in the act of muscular contraction. The general conclusion to be drawn from these researches is, therefore, that the chemical action which accompanies muscular contraction develops in living bodies, as in the pile or in a steam-engine, heat, electricity, and *vis viva*, according to the same mechanical laws.

Allow me to describe to you briefly the only one of these experiments which can be repeated in a lecture, and which proves the principal fact of these researches, although it is limited to prove that muscles in contraction develop a greater quantity of carbonic acid than those in repose. Take two wide-mouthed glass phials of equal size, 100 or 120 cub. centims.; pour 10 cub. centims. of lime-water (eau de chaux) into each of these phials. Prepare ten frogs in the manner of *Galvani*, that is, reducing them to a piece of spinal marrow, thighs and legs without the claws, which are cut in order to avoid contact with the liquid in the phials. The cork of one of these phials is provided with five hooks, either of copper or iron, on which five of the prepared frogs are fixed. Through the cork of the other phial are passed two iron wires, bent horizontally in the interior of the phial; the other five frogs are fixed by the spinal marrow to these wires. This preparation must be accomplished as rapidly as possible, and both the phials be ready at the same instant, and great care taken to avoid the contact of the frogs with the sides of the phials or the liquid. When all is in readiness, with a pile of two or three elements of Grove, and with an electro-magnetic machine such as is employed for medical purposes, the five frogs suspended on the two iron wires are made to contract. After the lapse of five or six minutes, during which time the passage of the current has been interrupted at intervals in order to keep up the force of the contractions, agitate gently the liquid, withdraw the frogs, close rapidly the phials, and agitate the liquid again. You will then see that the lime-water contained in the phial in which the frogs were contracted is much whiter and more turbid than the same liquid contained in the other phial in which the frogs were left in repose. It is almost superfluous to add, that I made the complete analysis of the air in contact with the frogs according to the methods generally employed.

2. *Selenium.*—Crystalline form according to Mitscherlich (J. f. pr. Chem. lxvi, 257) is monoclinic. $I : I = 64° 56'$, $i2 : i2$ (planes beveling front edge) $= 103° 40'$, C (or $O : ii$) $= 104° 6'$, $O : \frac{1}{2}i$ (clinodome) $= 142° 54'$, $O : 1 = 124° 48'$, $O : -1 = 112° 36'$.

3. *Iodine.*—Crystalline form (Mitscherlich, J. f. pr. Chem. lxvi, 265) trimetric; $I : I = 112° 48'$, $O : 1 = 112° 4'$, $O : 1\bar{i} = 126° 13\frac{1}{2}'$, $O : 1\bar{i} = 115° 57'$, $1\bar{i} : 1\bar{i}$ (top) $= 72° 27'$, $1\bar{i} : 1\bar{i}$ (top) $= 51° 54'$.

II. MINERALOGY AND GEOLOGY.

1. *Meteoric Iron of Thuringia.*—Description and analysis by W. Eberhard, (Ann. Ch. u. Pharm., xcvi, 286.)—Found on the 18th of October, 1854, near Tabarz, near the foot of the Inselbergs, not far from Gotha, and said to be still hot when picked up, though this is doubted. The mass is a small one, and is oxydized over the surface. It resembles much

that of Bohumilitz. In the outer crust, there are pieces of schreibersite and protosulphuret of iron. The Widmannstädtian figures are large. G.=7·737. Composition of this and the Bohumilitz irons:

	Fe	Ni	Co	Ph	Schreibersite
1.	92·757	5·693	0·791	0·862	0·277 = 100·380
2. Bohumilitz.	92·173	5·667	0·235	——	1·625 = 100, Berzelius.

2. *Meteoric Iron of Cape of Good Hope.*—Analyses by Uricoechea and Böcking (Ann. Ch. u. Pharm., xcvi, 246):—

	Fe	Ni	Co	Ph	Cu, Zn, S		
1. Uricoechea,	81·20	15·09	2·56	0·09	*trace*	Schreibersite,	0·95=99·89
2. Böcking,	81·30	15·23	2·01	0·88	*trace*	"	0·88=99·50

3. *Meteoric Stone of Mezö-Madaras in Siebenburg.*—Analysis by F. Wöhler (Ann. Ch. u. Pharm., xcvi, 251):—Native iron 18·10, nickel 1·45, cobalt 0·05, graphite 0·25, magnesia 23·83, Ḟe 4·61, Ṁn 0·28, Ä̇l 3·15, Ċa 1·80, Ṅa 2·34, K̇ 0·50, sulphur, phosphorus, and oxyd of chrome undetermined, silica 43·64=100. Separating 19·6 p. c. of nickeliferous iron, the rest was subjected to muriatic acid. The insoluble part and soluble part gave:

		S̈i	Ä̇l	Ṁg	Ḟe	Ċa	Ṅa	K̇	Graphite
1. Insoluble,		18·502	0·564	4·660	4·643	0·929	0·585	0·347	0·250=30·480
	In 100 parts,	60·70	1·85	15·29	15·25	3·05	1·91	1·13	0·82 =100
2. Soluble,		26·386	2·586	19·170	——	0·870	1·755	0·153	=50·920
	In 100 parts,	51·84	5·08	37·64	——	1·70	3·44	0·30	=100

The author concludes that the stone consists of olivine, augite, labradorite, with nickeliferous iron, sulphuret of iron, graphite, and a small proportion of chromic iron.

The meteorite fell on the 4th of September, 1852.

4. *On the Volcanoes of Southern Italy;* by M. C. St. Claire Deville (L'Institut, No. 1173).—M. Deville has prepared a report on his two journeys to the volcanic region of southern Italy. In connection with MM. Leblanc and Lewy, he has analyzed the gases and specimens collected by him, and the following are some of the results.

The gas of the fumaroles which he calls *dry fumaroles*, and of those that usually afford alkaline anhydrous chlorids with some sulphates, is pure air deprived of a very small proportion of oxygen. The gas analyzed was collected at Vesuvius in May, June, September and October, 1855.

The gas collected in September, 1855, from one of the fumaroles of the crater over the small central plain, from which vapor of water with sulphur and sulphuretted hydrogen were issuing, afforded, one specimen, 3·51 p. c. of carbonic acid; another 9·26 p. c. The rest was pure atmospheric air, or air deprived of its oxygen.

Two specimens of gas collected on the 5th and 22nd of October from the Lake Naftia in Sicily gave for the first, Oxygen 17·36, nitrogen 82·64; the second, oxygen 15·77, nitrogen 79·23, carbonic acid 5·00, showing the variations in the gaseous emanations.

The white mineral of the Vesuvian lava of recent eruptions is probably leucite, it having the specific gravity 2·48, and the oxygen ratio for the bases and silica 3 : 8·2. But it differs from the leucite of Somma in containing more potash, the oxygen ratio of the soda and potash being 1 : 2·09 in this mineral from the lava of 1855, and in the Somma (Fossa Grande) leucite 1 : 821. Moreover in the crystals from the lava of 1847, as he learns from M. Damour, this ratio is 1 : 1·67.

5. *On the Isthmus of Suez;* by M. RENAUD, (L'Institut, No. 1173.)—The greatest elevation of the isthmus of Suez above the Mediterranean is 16 meters, and this extends along only for a few miles. Between this higher part and the Gulf of Suez on the Red Sea, there are two depressions, one, the basin of the Bitter Waters, dry; the other, called Lake Timsah, occupied with water which when flooded flows towards the Nile along the Wady Toumilah. The height of land between these two basins is 11 meters above low tide in the Mediterranean; and the height between Lake Timsah and the Gulf of Peluse is but 9 meters. The distance across the isthmus in a straight line from the Gulf of Suez to the Gulf of Peluse is 113 kilometers (70 miles). It is a sandy and nearly barren region, to the north more gravelly. The southern half is completely sterile; the northern produces the vegetation peculiar to the deserts, on which the camels feed. On the borders of Lake Tismah, over the dry parts of its bed, and on the channel leading to Wady Toumilah, tamarinds grow in abundance. The sands of the isthmus are fixed, that is, not movable, and there are therefore no dunes. In some places there are minute disseminated crystals of gypsum, and also deposits of the same 6 to 15 inches thick; in other places concretions of carbonate of lime occur over the surface of the sand, and on some sand hills, one or two beds of limestone having the appearance of quartz.

In the north part of the basin where it was deepest, there is a deposit of salt 7½ meters thick, struck in sounding No. 10; and in sounding No. 9, salt was found covered by a bed of gypsum in fine needle crystallizations.

In the region between the Bitter lake basin and the Red Sea, there were encountered below the sand, compact clay, sandy clay, sand and gravel, laminated clay, &c. In the second sounding, a band of calcareous rock was found resting on one of sand. A marly clay was found in a third sounding. But in general, the clays hardly effervesced at all with acids. Beyond the Bitter lake basin there were only sands, excepting in sounding 19, a band of marl.

In the basin of the Bitter lake, shells occur like those of the Red Sea, among which a species of Mactra is very common. It is probable that these shells have not lived in the waters since the basin was shut off from the tides of the Red Sea, since the hot climate, after such a separation, would soon concentrate the waters by evaporation and so destroy all living species. It is true that in the time of Strabo and Herodotus the basin contained water: but it was fresh water which was brought there by the canal joining the Nile and Red Sea. It is a controverted question whether the lakes were yet a part of the Red Sea when the Jews under Moses left Egypt. The affirmative accords best with the sacred text; but then, the elevation of Suez must have taken place since that event.

The banks of the sea as well as the soil of the isthmus show no evidence of marked change since the most remote periods. The sand and shells of the present beach look very different from those of the interior, and contain many shells not found in the latter. These seashore sands have a width nowhere exceeding 100 meters. There is still more evidence on the Gulf of Peluse that there has been no change of level since the earliest historical period.

6. *On the Mines of Mineral Coal in Peru;* by M. E. DE RIVERO.*—The works published on Peru scarcely make any mention of the Peruvian Coal Mines. I propose to supply this deficiency of information, at least in part, by some account of the beds which I have seen in the Cordillera, some of which I have myself discovered.

Along the Coast district, although coal occurs in some places, it has not been found in mines of workable value. This remark applies to the island of San Lorenzo near Callao, and the district of Tumbès. Still, we believe that a careful survey may yet bring to light beds of value which will well repay the expense of exploration, since coal is so essential to industry, and especially to the Peruvian steamers, which are now compelled to import it from England at great expense.

The discovery of the coal mines of Peru dates from the introduction of steam engines which were established by the Company of Abadia in 1816 in the *Cerro de Pasco*, department of Junin. The first bed was discovered by Hudille in the hill called *Rancas*, two leagues from Cerro. At first it was not known what to do with the coal; for charcoal and peat were employed in their kitchens and forges, and for the distillation of the silver amalgam. But afterwards, on its coming into use for engines, it was gradually introduced for domestic purposes, the district affording little wood; and now there is only a single house in which a fire-place is constructed for burning charcoal. The climate of the *Cerro del Pasco*, a place situated 4,352 meters above the sea, is consequently more supportable.

The coal beds of Rancas have a north and south direction and a dip to the west. They overlie shales and sandstones and are covered by the same rocks. There are many flexures and faults, as in the coal regions of Belgium and elsewhere. The principal bed is quite large; the coal is excellent, giving much flame and little residue, and serving well in forges; its structure is not as schistose as usual.

Other beds have since been discovered. Two leagues from Cerro, in the peak of *Colquyilca*, there are three coal beds of moderate thickness and good quality. At the Quebrada of *Fulluranca*, on the road from Huanuco, in the peaks of Puelles, Anaspuquio and Siricancha, near the property belonging to Don Gaspar Sola, there are considerable beds which are used for heating houses and also for the *pella* of silver. They occur between sandstone and a limestone which contains galena. Not far distant, I have found a greenish fluor associated with the galena.

In the direction of the silver mine of Vinchos, (a mine worked extensively and with great profit), on the ascent of the peak of *Pargas*, at a place called Curaopuero, there is a coal bed 15 varas (41·7 feet) thick. The coal is but little bituminous, and it burns easily, leaving a white slaty residue. The mine belongs to MM. Sanchez and Don Ricardo Joch.

Four leagues from this point, to the right, stands the peak of Pictichaca (a word signifying *bridge*.) at the foot of which there are the lakes of Geguey and Boliche. It contains the silver mines of *Rosario*, belonging to the lands of Jarria, and other mines which it is said have been explored by a Portuguese company.

* Ann. des Mines, [5], vii, 1855, p. 459.

On the descent of the Quebrada de Vinchos, in the peak of *Churca*, there is a bed of coal which I discovered. I believe it to be of good quality, although of little thickness. Near the village of *Pallanchaca*, there is an important bed which is yet to be explored.

The extensive silver mine of *Huallanca* has near it beds of mineral coal, 4 to 5 varas thick, and of excellent quality; and it is probable that manufactories and founderies will consequently be established. The height of Huallanca above the sea level is 3,527 meters. Near the quicksilver mine of *Chonta*, at a height of 4,465 meters, there are beds of coal, hitherto explored only for heating. They rest on sandstone and alternate with conglomerate and iron pyrites.

Coal is also found in the profound Quebrada of *Queropalca*, a region very rich in metals, especially lead; also in *Chavin de Guanta*, celebrated for its famous castles of the ancient Incas. Near the mine of Oyon, Province of Cajatambo, several beds of superior quality have been explored, covering many leagues. The old mine of antimonial sulphuret of silver, lying upon magnesian carbonate of lime, and whose exploration has lately been undertaken by an American (U. S.) company, has not responded to their expectations. The village of Oyon is 3,621 meters above the sea level.

In the hill of *La Vinda*, on the road from Obragillo to Cerro de Pasco, at an elevation of 4,613 meters, I have observed coal in horizontal beds between sandstone and shale, containing fossil shells which were too imperfect to make out the species. There is coal also in the villages of Marcapopacocha, Alpamarca, Pallanea, etc.

Twelve leagues from Cerro, there is the coal bed of *Cullutago*, extending on both sides of the Quebrada of the village of Huallay enclosed by the elevations of Andacancha and Anascacha; the bases of these elevations are of sandstone, while the summits consist of white trachyte containing bits of greyish perlite and white transparent quartz. Before arriving at Huallay, ores of silver and mineral coal are met with on the road. Coal also occurs in the peak of Chicacha, which contains also mines of silver. The base of the mountain is remarkable for a saliferous marl, the source of several salt springs or streams.

In the peak of *Aranvaldpan*, there are several other mines of good coal, which were opened by the Company of Abadia for the smelting of argentiferous galena. There is another near the small lake of Pichac, explored by M. Alexander Verastegui, but of inferior quality. Near Huaypacha, there is a bed of lignite. At Chapalca, near Puipuy, coal exists in a bed of considerable extent; also of superior quality and extent near Huayay. Coal is also said to occur in the road from Farma to Jauja, and at the Quicksilver mine of Huancavelica.

Some years since, coal beds were discovered at the Quebrada of Murco, in the department of Arequipa. This Quebrada, the commencement of the Valley of Siguas, takes its origin at the foot of the high and majestic Nevado de Sallaly, whose summit is covered with perpetual snow and will never be scaled by man. I think that the height is greater than that of the volcano of Arequipa, which is 6,600 meters. All travelers who pass the foot towards Lampa or Puno, suffer from extreme cold and dizziness from the rarity of the atmosphere, causes which in some seasons

have occasioned the death of the animals themselves. The Quebrada of Murco trends from the northwest to the southeast, and consists, as far as in view, of sandstone and black schist. Fifty *ranchos* (huts of straw or stone) are occupied by the natives in charge of their herds, and this is all the population. They cultivate Indian corn, poor peaches, together with the Chilca (Eupatoria resinosa) a shrub that grows abundantly and which dug into the ground makes an excellent fertilizer. At four to six *cuadras* from these *ranchos*, on the banks of a stream which is impassable in the rainy season, there are some beds of coal in the slate, which dip to the north, the strike east-southeast and west-northwest. They are explored at the surface for a breadth of some varas, and are associated with ironstone and pyrites. I have observed other beds near, which appear to be of better quality. One explored under the direction of M. Uria, has a breadth of more than a yard, and the coal has been tried in the Pacific steamers. It is carried to Arequipa, 15 to 16 leagues, for the forges there in operation. I believe that it will soon be employed in the valleys of Siguas and Vitor for the distillation of wine.

In the valley of Mages, near the property of Querulpa, I have found in a limestone a small and nearly horizontal bed of coal which I have left to Manuel Reyes to explore. In the Quebrada of the warm springs of Yura, nine leagues north of Arequipa, I found, in 1827, coal in a blackish schist like that of Compuerta, on the road from that village to Puno. There are said to be other beds at Esquino, on the route from Moquega, and at Morro on the way from Sama. From the nature of the beds, coal may yet be found near Arica. There are still other places in La Costa or the Coast Region, where it may be found.

Thus Peru is not destitute of beds of mineral coal. But owing to the great distances and the want of roads, the industrial establishments of the coast are still compelled to provide themselves from foreign dealers at great expense, paying 20 to 25 dollars a ton.

7. *Waters of Lake Ooroomiah;* by HENRY WITT, (Phil. Mag. [4], xi, 257)—The waters of Lake Ooroomiah examined, were collected by Mr. W. K. Loftus. The lake, he says, is "about 82 miles in length and 24 wide, its height being 4100 feet above the level of the sea. The water is of a deep azure color, but there is something exceedingly unnatural in its heavy stillness and want of life. Small fragments of Fuci, saturated with salt, and thrown ashore, form a ridge at the margin of the lake, and emit such a noxious effluvium under a hot sun as to produce nausea at the stomach. The sulphuretted hydrogen generated from the lake itself without doubt adds to this sensation. The water is intensely salt, and evaporates so rapidly, that a man, who swam in to bring me a bottle of the water for analysis, on coming out was covered with particles of salt, and looked as white and ludicrous as though he had been thrown into a flour tub."

The sample was taken from the lake at Guverjin Kalah, on the north-western shore, on the 14th of August, 1852, the temperature of the water at the time being 78° F. at 11 A. M.

As I received it (the cork having been well secured by a coating of wax), the water still retained a strong smell of sulphuretted hydrogen, and was moreover supersaturated with carbonic acid, which it evolved on being

shaken or gently heated. It was evidently a very strong brine, for it tasted intensely of common salt, and left on every place on which a drop evaporated spontaneously a large quantity of saline residue. On leaving a portion of it for a few hours in a warm laboratory in an open dish, large cubical crystals, exhibiting the peculiar step-like cavernous structure of common salt, separated in abundance.

Its specific gravity was 1·18812, and on evaporation it gave a total quantity of solid residue amounting to 21856·5 *grains in the gallon.*

In the imperial gallon (of 70,000 grains) there were present 10470·439 grains of chlorine, corresponding to 17254·27 grains of common salt; the remainder of the saline matter, amounting to 4602·23 grains, consisted chiefly of alkaline carbonates, but also contained small quantities of the sulphates and carbonates of lime and magnesia; the smallnes of the quantity of water in my possession prevented the possibility of determining their actual amount.

To indicate the position of the Lake of Ooroomiah among natural brines, I append a table showing the specific gravities, total quantities of solid residue, and of common salt, in the gallon of several of the mineral springs of Harrogate (analysed by my friend Mr. Northcote and myself

Name of water.	Specific gravity.	Total residue in the gallon, in grains.	Common salt in the gallon in grains.	Authority.
Seas :—				
The Mediterranean....	....	2870	....	Pfaff, 1839.*
do.	....	2851	1905	Laurens, 1839.†
do.	1·0287	....	....	A. H. and R. Schlagintweit, 1854.‡
English Channel.....	....	2660	....	Pfaff.
do.	....	2468	1890	Schweitzer, 1839.†
German Ocean at the Frith of Forth....	....	2174	....	Pfaff.
Baltic Sea at Kiel in Holstein	....	1400	....	do.
Atlantic.....	1·027	....	....	A. H. and R. Schlagintweit.
Red Sea	1·0315	....	....	do.
Brines :—				
Harrogate Springs.				
1. Old Sulphur well...	1·01113	1096	866	Hofmann, 1854.§
2. Montpelier strong sulphur well...	1·01045	966	803	do.
3. Hospital strong sulphur well...	1·00515	437	369	do.
Dead Seas	1·211	17220	....	Marcet.‖
Droitwitch brine	1·1893	20157	19392	A. B. Northcote, 1855.¶
Stoke brine	1·2044	22256	21492	do.
Lake of Ooroomiah	1·11812	21856	17254	H. M. Witt, 1856.

* Pfaff, Schwartze's *Allgemeine und speciells Heilquellenlehre.* Leipsic, 1839.

† Laurens and Schweitzer, Phil. Mag., [3], vol. xv, p. 51.

‡ Phil. Mag. for 1855, vol. ix, p. 396, "On the Temperature and Density of the Seas between Southampton and Bombay."

§ Hofmann, Quart. Journ. of Chem. Soc., vol. vii, p. 161.

‖ Marcet, Nicholson's Journal, vol. xx, p. 25.

¶ Northcote, Phil. Mag. Jan. 1855.

for, and under the direction of, Dr. Hofmann), as well as of other brine-springs, and the waters of certain seas.

The extreme saltness of this and the neighboring lakes would appear to arise from the separation, at some remote period, of these masses of salt water from the main ocean, together with the great Caspian and Aral lakes; and the continued evaporation by constantly diminishing their volume (as has been proved by observations on the spot) has caused them ultimately to become, as they are, perfectly saturated brines: and Mr. Loftus states that there are other lakes in the neighborhood which have completely dried up, leaving nothing but a great bed of salt.

8. *On the Koh-i-Noor Diamond*, (from the Proceedings of the Ashmolean Society, Feb. 12, 1855).—The Secretary (M. Maskelyne) made a communication on the history of the Koh-i-Noor diamond. After recounting the fabulous and traditionary accounts of it existing still in India, whereby its antiqnity was carried back to the Indian hero Bikramaditya, 56 B. C., and even to the fabled age of Krishna, he drew attention to the account of a large diamond described by Baber, the founder of the Mogul dynasty, in his memoirs, the authenticity of which is unquestionable. He mentions it as a part of the spoil taken by his son, Hûmayûn at Agra, after that battle of Paniput, in which Ibrahim Lodi fell, and with him his ally or tributary the Rajah of Gwalior Bikramajit, custodian of the fortress of Agra. It is reported by Baber to have come into the Delhi treasury from the conquest of Malwa by Ala-ed-deen in 1304.

Baber gives its weight as about 8 mishkâls. In another passage he estimates the mishkâl at 40 ratis, which would make its weight 320 ratis. It is singular that Tavernier describes a diamond which he saw in 1665 among the crown jewels of Aurungzebe, as having exactly this weight, or rather as weighing 319½ ratis. To this diamond, however, he assigns another history, making it identical with a huge diamond said to have been given by Meer Jumla, the King of Golconda's Minister, to purchase the good will of Shah Jehaun, preparatory to his exchanging into his service from one in which it was no longer safe for him to remain. This diamond is alluded to by Bernier also, and seems to have had a real existence, though Tavernier's account of its cutting admits to its having been greatly injured, and possibly leads to the inference that it was ruined in the process. In order to make out which of these two historic diamonds is the Koh-i-noor, Mr. Maskelyne went minutely into Tavernier's description, comparing it with his drawing of it, and with his own language in another place. He showed that Tavernier's accounts of the exhibition to him of the jewels of Aurungzebe differed slightly in themselves, and entirely from his drawing of the diamond; but that the former, on the whole, represented with singular fidelity the original appearance of the diamond now in England, supposing it to be mounted in such a manner as to conceal the lower part of it. It seemed probable, however, from another reason, that the diamond Tavernier saw was not the one he imagined it to be, and of which he had doubtless heard descriptions in the mines of Golconda, but the diamond of Baber. Aurungzebe held his father a state prisoner. Shah Jehaun had been asked by his unfilial conqueror to give him some of the splendid jewels which he retained in his captivity; at first, indignantly refusing, Shah Jehaun threatened to de-

stroy them; but afterwards,—"some time before his death"—he surrendered some of them, but kept many. After his death these were given to Aurungzebe by his sister Jehanira. Would Shah Jehaun have given to Aurungzebe or would he have retained a diamond, (supposing it to have escaped destruction, in the cutting,) which had been the price of his interference with the affairs of Golconda, and had been perhaps the ultimate cause of his son's triumph over him? Far more probably would he have given him the true Mogul diamond, the proudest jewel of the conquests of his great ancestor, and that to which Aurungzebe stood indefeasibly, though by fratricide truly Indian, the unnatural heir. Tavernier saw the jewels of Aurungzebe on Nov. 3, 1665. Shah Jehaun died in February, 1666. Tavernier saw but one very large diamond. The dates agree with the supposition; and there are not likely to have been two diamonds, one of 320, the other of 319½ ratis.

It is very difficult to determine the weight of the rati. It is variable in place and time, and, in many places is a conventional weight. The rati is the *Abris precatorius* or *rutka*, a little red seed with a black tip to it, which was, like our barleycorn, a standard of weight over all India, which however varied from about 1·86 of a grain up to 2·25 grains; the coins of Akbar leading to the inference of its weight being nearly 1·9375 of a grain. It is obviously useless to multiply so small a number by 120, for we could expect no accurate result, owing to the exaggeration of the error arising from the multiplication of even the smallest mistake in the true weight of the rati in Baber's or Tavernier's time. But the eight mishkâls of Baber afford a far more hopeful estimate of the weight of the diamond. This is a Persian weight, and seems to be and to have been far less liable to fluctuation or variety in value at different times or places. The Persian mishkâl, or half-dirhem, weighs 74·5 grains troy, and eight of these equal 596 grains, or 187·58 carats.* The Koh-i-Noor in the Exhibition of 1851 weighed 186 carats. This would require a weight of 1·848 grains for the rati, a number nearly approximating to that given by the coins of Akbar.

Accepting then the conclusion, that the great diamond which was the spoil of Ala ed Deen in 1306, and had probably been for ages the crown jewel of the independent Rajahs of Malwa, passed to the Mogul conqueror of the Pathan sovereigns, and was so inherited by the Mogul emperors, and was seen in their possession by Tavernier in the reign of Aurungzebe; Mr. Maskelyne went on to trace its subsequent history.

It remained at Delhi, until another, the fiercest and the last of the great inroads of Western Tartar peoples, broke over the hills of Affghanistan, and flooded the plains of North Western India.

The history of Thamas Kouli Khan, Nadir Shah, is sufficiently near to the present time to fall almost within the field of European contest in India. This conqueror from the west gave back the prostrate empire of India to his Tartar "kinsman" on the throne of Delhi, and exchanged turbans with him,—so says tradition,—in sign of eternal amity. The proud diamond of the Moguls was in the cap of the vassal, and was saluted by the title of Koh-i-Noor, "Mound of Light" by his suzerain. It went back

* The carat = 3·17 grains Troy weight.

with all the fabulous wealth the Persian host bore with them to Khorassan. From Nadir Shah it passed into the hands of his powerless representative Shah Rokh; but it was not one of the jewels afterwards extorted from him by such frightful torture. The history of Ahmed Shah, founder of the short-lived Douranee empire, is that of many other historic names. The realms conquered by Nadir fell asunder at his death; and the Affghan, captain of his horse and lord of his treasure, secured for himself the kingdoms surrounding his native passes, and erected them into an empire, which extended from Moultan to Herat, from Peshawur to Candahar. From his Affghan eyrie he descended to aid his old master's son in the hour of his adversity, sealed an alliance with him, and bore back the great diamond whose beauties "its blind owner could no longer see," and which became once more an equivocal symbol of friendship between sovereigns of whom the recipient of the diamond was the stronger. From Ahmed Shah it descended with the throne to his sons. The wild romance of Shah Soujah's life was in no small degree linked with this gem. Long hidden in the wall of a fortress that had been Shah Zemaun's prison, it shone on the breast of Shah Soujah when the English embassy visited Peshawur. Mahmoud reasserted with success the claim of might to the empire of his brother, and Shah Soujah became an exile. But his companion in that exile was the Koh-i-Noor, and, hunted from Peshawur to Cashmere, and decoyed from Cashmere to Lahore, Shah Soujah became in semblance the guest, in reality the prisoner, of Runjeet the Lion. He disgorged the prize for the sake of which the lord of the five rivers had inveigled him to his lair: and the ex-king of Caubul and Douranee prince escaped the gripe of his savage tyrant only to enter on adventures, the story of which might for incident and hardship challenge the pages of romance. The Koh-i-Noor had again been true to its tradition. It had passed from the weak to the strong under the semblance of righteousness. "At what do you estimate its value?" said Runjeet to his victim. "At good luck," replied Shah Soujah, "for it hath ever been the property of him that hath conquered his enemies." The successors of Runjeet Sing inherited the Koh-i-Noor, and when the Sikh power fell before the arms of England, which it had challenged, the talisman of Indian sway passed from the treasury of Lahore to the jewel-chamber of Windsor; and reposes once again, as the proudest jewel in the tiara of Indian empire. But it is no more the Mountain of Light. It is no longer the finest diamond known in the world: it has been recut, as well perhaps as it was possible to recut it*, and is now a brilliant, weighing but 103 carats. Although no more the 8 mishkâls of Diamond that Baber valued at half the rent-roll of a world, it is the identical gem that has contributed its light to the glories of every dynasty that has dazzled the East by the supremacy of its arms for perhaps a thousand years.

9. *On the origin of Greensand, and its formation in the Oceans of the present epoch;* by Prof. J. W. Bailey, (Proc. Bost. Soc. Nat. Hist., vol. v, p. 364.)—As an introduction to the subject of this paper, it is proper to refer to various observations which have been made of facts intimately

* The artistic part of the work, performed by Dutch artists under the superintendance of Messrs. Gerrard, the Queen's Jeweller, was admirably executed.

related to those which I wish to present. That the calcareous shells of the Polythalamia are sometimes replaced by silica, appears to have been first noticed by Ehrenberg, who, in a note translated by Mr. Weaver, and published in the L., E. and D. Philosophical Journal for 1841, (vol. xviii, p. 397,) says :—

"I may here remark that my continued researches on the Polythalamia of the Chalk, have convinced me that very frequently in the earthy coating of flints, which is partly calcareous and partly siliceous, the original calcareous shelled animal forms have exchanged their lime for silex without undergoing any alteration in figure, so that while some are readily dissolved by an acid, others remain insoluble; but in chalk itself, all similar forms are immediately dissolved."

The first notice of *casts* of the cells and soft parts of the Polythalamia was published by myself in the American Journal of Science for 1845, vol. xlviii, where I stated as follows :—

"The specimens from Fort Washington presented me with what I believe have never been before noticed, viz: distinct *casts* of Polythalamia. That these minute and perishable shells should, when destroyed by chemical changes, ever leave behind them indestructible memorials of their existence was scarcely to be expected, yet these casts of Polythalamia are abundant and easily to be recognized in some of the Eocene Marls from Fort Washington." This notice was accompanied by figures of well-defined casts of Polythalamia (l. c. pl. iv, fig. 30, 31).

Dr. Mantell also noticed the occurrence of casts of Polythalamia and their soft parts, preserved in flint and chalk, and communicated an account of them to the Royal Society of London, in May, 1846. In this paper he speaks of the chambers of Polythalamia as being frequently filled with chalk, flint, and *silicate of iron.* (Phil. Trans., 1846, p. 466.) To Ehrenberg, however, appears to be due the credit of first distinctly announcing the connection between the Polythalamia and the formation of Greensand, thus throwing the first light upon the origin of a substance which has long been a puzzle to geologists. In a notice given by this distinguished observer upon the nature of the matrix of the bones of the Zeuglodon from Alabama, (see Monatsbericht, Berlin, February, 1855,) he says :—

"That Greensand, in all the numerous relations in which I have as yet examined it, has been recognized as due to the filling up of organic cells, as a formation of stony casts (Steinkernbildung) mostly of Polythalamia, was stated in July of the preceding year." He then refers to the Nummulite Limestone of Traunstein in Bavaria, as rich in green opal-like casts (Opalsteinkernen) of well-preserved Polythalamian forms, and mentions them as also occurring, but more rarely, in the Glauconite Limestones of France. He then proceeds to give an account of his detection of similar casts in the limestone adhering to the bones of the Zeuglodon from Alabama, and states that this limestone abounds in well-preserved brown, green, and whitish stony casts of recognizable Polythalamia. This limestone is yellowish, and under a lens appears spotted with green. These green spots are the Greensand casts of Polythalamia, and they often form as much as one-third of the mass. By solution in dilute chlorohydric acid, the greensand grains are left, mixed with quartzose sand, and

with a light yellowish mud. The latter is easily removed by washing and decantation. The casts thus obtained are so perfect that not only the genus, but often the species of the Polythalamia, can be recognized. Mingled with these are frequently found spiral or corkscrew-like bodies, which Ehrenberg considers as casts of the shells of young mollusks.

With reference to the perfection of these casts of the Polythalamia, and the light they throw upon the structure of these minute animals, Ehrenberg remarks :—

"The formation of the Greensand consists in a gradual filling up of the interior space of the minute bodies with a green-colored, opal-like mass, which forms therein as a cast. It is a peculiar species of natural injection, and is often so perfect, that not only the large and coarse cells, but also the very finest canals of the cell walls, and all their connecting tubes are thus petrified, and separately exhibited. By no artificial method can such fine and perfect injections be obtained."

Having repeated the experiments of Ehrenberg upon the Zeuglodon limestone, I can confirm his statements in every particular, and would only add, that besides the casts of Polythalamia and small spiral mollusks, there is also a considerable number of green, red, and whitish casts of minute anastomosing tubuli, resembling casts of the holes made by burrowing sponges (Cliona) and worms.

In the Berlin Monatsbericht, for July, 1855, Ehrenberg gives an account of very perfect casts of Nummulites, from Bavaria and from France, showing not only chambers connected by a spiral siphuncle, but also a complicated system of branching vessels. He also gave at the same time an account of a method he had applied for the purpose of coloring certain glass-like casts of Polythalamia, which he had found in white tertiary limestone from Java. This method consists in heating them in a solution of nitrate of iron, by means of which they can be made to assume different shades of yellow and brownish red, still retaining sufficient transparency when mounted in balsam to show the connection of the different parts.

The interesting observations of Ehrenberg which are alluded to above, have led me to examine a number of the cretaceous and tertiary rocks of North America in search of Greensand and other casts of Polythalamia, &c. The following results were obtained :—

1st. The yellowish limestone of the cretaceous deposits of New Jersey occurring with Teredo tibialis, &c., at Mullica Hill, and near Mount Holley, is very rich in Greensand casts of Polythalamia and of the tubuliform bodies above alluded to.

2d. Cretaceous rocks from Western Texas, for which I am indebted to Major W. H. Emory, of the Mexican Boundary Commission, yielded a considerable number of fine Greensand and other casts of Polythalamia and Tubuli.

3d. Limestone from Selma, Alabama, gave similar results.

4th. Eocene limestone from Drayton Hall, near Charleston, South Carolina, gave abundance of similar casts.

5th. A few good Greensand casts of Polythalamia were found in the residue left on dissolving a specimen of marl from the Artesian Well at Charleston, S. C.; depth 140 feet.

6th. Abundance of organic casts, in Greensand, &c., of Polythalamia, Tubuli, and of the *cavities of Corals*, were found in the specimen of yellowish limestone, adhering to a specimen of Scutella Lyelli from the Eocene of North Carolina.

7th. Similar casts of Polythalamia, Tubuli, and of the *cavities of Corals*, and spines of Echini, were found abundantly in a whitish limestone adhering to a specimen of Ostrea sellæformis from the Eocene of South Carolina.

The last two specimens scarcely gave any indications of the presence of Greensand before they were treated with dilute acid, but left an abundant deposit of it when the calcareous portions were dissolved out. All the above mentioned specimens, contained well-preserved and perfect shells of Polythalamia. It appears from the above, that the occurrence of well-defined organic casts, composed of Greensand, is by no means rare in the fossil state.

I come now to the main object of this paper, which is to announce that the formation of precisely similar Greensand and other casts of Polythalamia, Mollusks, and Tubuli, is now going on in the deposits of the present ocean. In an interesting report by Count F. Pourtales, upon some specimens of soundings obtained by the U. S. Coast Survey in the exploration of the Gulf Stream, (See Report of U. S. Coast Survey, for 1853, Appendix, p. 83,) the sounding, from Lat. 31° 32′, Long. 79° 35′, depth 150 fathoms, is mentioned as "a mixture in about equal proportions of Globigerina and black sand, probably greensand, as it makes a green mark when crushed on paper." Having examined the specimen alluded to by Mr. Pourtales, besides many others from the Gulf Stream and Gulf of Mexico, for which I am indebted to Prof. A. D. Bache, the Superintendent of the Coast Survey, I have found that not only is Greensand present at the above locality, but at many others, both in the Gulf Stream and Gulf of Mexico, and that this Greensand is often in the form of well-defined casts of Polythalamia, minute Mollusks, and branching Tubuli, and that the same variety of the petrifying material is found as in the fossil casts, some being well-defined Greensand, others reddish, brownish, or almost white. In some cases I have noticed a single cell, of a spiral Polythalamian cast, to be composed of Greensand, while all the others were red or white, or *vice versa*.

The species of Polythalamia whose casts are thus preserved, are easily recognizable as identical with those whose perfectly preserved shells form the chief part of the soundings. That these are of recent species is proved by the facts that some of them still retain their brilliant red coloring, and that they leave distinct remains of their soft parts when treated with dilute acids. It is not to be supposed, therefore, that these casts are of extinct species washed out of ancient submarine deposits. They are now forming in the muds as they are deposited, and we have thus now going on in the present seas, a formation of Greensand by processes precisely analogous to those which produced deposits of the same material as long ago as the Silurian epoch. In this connection, it is important to observe that Ehrenberg's observations and my own, establish the fact that *other* organic bodies than Polythalamia produce casts of Greensand, and it should also be stated that many of the grains of Greensand accompany-

ing the well-defined casts are of wholly unrecognizable forms, having merely a rounded, cracked, lobed, or even coprolitic appearance. Certainly many of these masses, which often compose whole strata, were not formed either in the cavities of Polythalamia or Mollusks. The fact, however, being established beyond a doubt, that Greensand does form casts in the cavities of various organic bodies, there is a great probability that all the masses of this substance, however irregular, were formed in connection with organic bodies, and that the chemical changes accompanying the decay of the organic matter have been essentially connected with the deposits in the cavities, of green and red silicates of iron, and of nearly pure silica. It is a curious fact in this connection, that the *siliceous* organisms, such as the Diatomaceæ, Polycistineæ, and Spongiolites which accompany the Polythalamia in the Gulf Stream, do not appear to have any influence in the formation of casts.

The discovery of Prof. Ehrenberg, of the connection between organic bodies and the formation of Greensand, is one of very great interest, and is one of the many instances which he has given to prove the extensive agency of the minutest beings in producing geological changes.

III. BOTANY AND ZOOLOGY.

1. *Wild Potatoes in New Mexico and Western Texas.*—We have received from Dr. A. J. Myer, U. S. A., through the Surgeon General, a detailed communication on the discovery in western Texas of what he takes to be the common potato (*Solanum tuberosum*, L.,) in a wild state, accompanied with specimens of the tubers and of the whole plant neatly dried and prepared. Dr. Myer first detected the plant on and near the Rio Limpio, and afterwards ascertained that it was pretty widely diffused throughout all that region and into New Mexico. The tuber, though small, being rarely as large as a hickory nut, have been gathered, cooked and eaten by officers and soldiers, and they proved to be both palatable and innocent. It naturally occurred to Dr. Myer that his discovery might be turned to useful account; that these wild potatoes would probably increase in size and improve in flavor under continued cultivation; and that, if the well-known potato-rot were owing, as many suppose, to an attack of minute Fungi, or to a general debility of constitution resulting from propagation for generation after generation by the tuber, and seldom renewed from seed, or from both these causes combined, the proper remedy would be to begin anew with a wild stock; and that these indigenous potatoes of our own country would furnish an excellent stock for the purpose, and one which might be expected to resist the disease for a long time, if not altogether.

Such, in brief, is the substance of Dr. Myer's commendable communication, made to his official superior, the Surgeon General, and by him offered for publication in this Journal. The article is too long to be inserted, however; especially as the facts and the suggestions it comprises have not the novelty which Dr. Myer naturally supposed they had. But his laudable endeavors and observations ought not to pass unnoticed; and having given this very brief abstract of his principal points,—which he

has ably but rather diffusely elaborated, we take the opportunity to remark :—

(1.) That the wild potato-plant in question is a true potato, but not of the same species as the common potato, the *Solanum tuberosum*. Indeed two tuberiferous species of Solanum occur in that region. One has a white and 5-parted corolla, and oblong-lanceolate leaflets mostly acute at the base, and is probably S. Jamesii of Torrey (which, if we are correct, was wrongly thought to be annual): the other, to which belong the specimens sent by Dr. Myer, has a blue, 5-lobed corolla, and ovate or roundish leaflets which are often a little heart-shaped at the base; and this if really undescribed, will soon be published under the name of *S. Fendleri*. Both are distinguished from *S. tuberosum* by having their leaflets uniform, or only the lowest pairs smaller, while in the common potato, and the 18 allied forms recognised by Dunal as species (but perhaps all mere varieties of one species,) a set of much smaller leaflets are interposed between the larger ones.

(2.) These wild potatoes have been known for some time. Passing by Dr. James, who gathered the one which bears his name, 36 years ago, but without knowing it was tuberiferous, we may attribute their proper discovery to that most excellent botanical explorer, Mr. Fendler, whose collection made nine years ago in the northern part of New Mexico, comprised both species, with their tubers. They were also gathered by Mr. Wright, in 1849, and are contained in his invaluable collection made between Eastern Texas and El Paso by the military road then opened through that region: and again in 1851 and 1852, they were gathered in various parts of New Mexico by Mr. Wright, Dr. Bigelow, and the other naturalists attached to the Mexican Boundary Commission, who recognised their near relationship to the common potato.

(3.) Some experience has already been had in cultivating other and nearly related species as a substitute for Solanum tuberosum, but without the good results that were hoped for. M. Alph. De Candolle relates (Prodr. 13, p. 677,) that the Mexican *Solanum verrucosum*, was cultivated two years in Switzerland, near Geneva, without being affected by the disease which destroyed all the crops of the common potato in the vicinity; but on the third year this also was attacked (Vide Alph. DeCand. Geogr. Bot., p. 815). A. G.

2. *Notes on Palæozoic Bivalved Entomostraca*, Nos. I. and II; on some Species of Beyrichia from the upper silurian limestones of Scandinavia and other regions British and Foreign; by T. Rupert Jones, F.G.S.—These important researches, illustrated by copper plates, are published in the Annals and Magazine of Natural History, for August and September, 1855.

3. *Cumæ*.—In a recent number of the Annals and Magazine of Natural History, Mr. Bates describes some Crustacea related to Cumæ, which had young and *therefore were adults*. This is not in conflict with the statement of Prof. Agassiz in this Journal, vol. xiii, p. 426, where he says: "In regard to the Crustacea called Cumæ, I cannot say positively that the group must as a whole be suppressed. But I can state with confidence that all the species of that genus which I have had an opportunity to examine alive—and I have watched three—are young of Palæmon

Crangon and Hippolyte." Prof. Agassiz in a recent letter (to J. D. Dana, dated Nahant, July 18th,) respecting these observations of Mr. Bates, writes that "they only show how extensive a field of observation remains untrodden among these little forms. Had Mr. Bates looked more fully into the embryology of Crustacea he would be better prepared to appreciate the close correspondence there is between the young of certain families and the adults of others, and know that these facts are not limited to the Macroura, as I have shown in my lectures on embryology, p. 62 to 69: he would know that the eyes of even the highest Crustacea are sessile in the young, etc., and that such characters observed upon young Crustacea do not therefore prove them to be peculiar types, unless at the same time their reproduction be satisfactorily traced. Acknowledging Mr. Bates's interesting observation as proving that his Diastylis Rathkii is an adult animal, the question has made a real progress through his researches; but it remains as certain as before, that *there are Cumæ which are larvæ of Macroura.*"

4. *Insecta Maderensia, being an Account of the Insects of the Islands of the Madeiran Group;* by T. Vernon Wollaston, M.A., F.R.S. 634 pp., 4to, with 13 well-filled colored plates. London, 1854. John Van Voorst.

On the Variation of Species with especial reference to the Insecta, followed by an inquiry into the Nature of Genera; by T. Vernon Wollaston, M.A., F.L.S. 208 pp., 12mo. London, 1856. John Van Voorst.

The first of these works is an elegant quarto volume containing full descriptions, of the Insects of the Madeira Islands, with remarks on their distribution, habits and varieties. The author went as an invalid to the regions he has so carefully investigated, and we rejoice with him in the invigoration he found in pursuing his favorite science among the heights and gorges of that delightful land. As giving some picture of the author, we quote a paragraph or two from his Introduction:—

"The admirer of Nature who has passed a long winter at the mountain's base, contented merely to gaze upon the towering peaks, which, though clear and cold at night, seldom reveal themselves during the day with sufficient constancy (through the heavy canopy of cloud which hangs around them) to warrant an ascent, hails with unbounded joy the advance of spring,—knowing that the time is at hand when he will be able to revel at large in this Atlantic paradise, in remote spots seldom visited by strangers, and at altitudes where the fierce elements of winter shall give way at last to perpetual sunshine and the fresh breezes of a calmer sea. There is something amazingly luxurious in betaking oneself to tent-life, after months of confinement and annoyance (it may be entirely,—*partially* it must be) in the heat and noise of Funchal. We are then perhaps more than ever open to the favorable impressions of an alpine existence;—and who can adequately tell the ecstasy of a first encampment on these invigorating hills! To turn out, morning after morning, in the solemn stillness of aërial forests,—where not a sound is heard, save ever and anon a woodman's axe in some far-off tributary ravine, or a stray bird hymning forth its matin song to the ascending sun; to feel the cool influence of the early dawn on the upland sward, and to

mark the thin clouds of fleecy snow uniting gradually into a solid bank,—affording glimpses the while, as they join and separate, of the fair creation stretched out beneath; to smell the damp, cold vapor rising from the deep defiles around us, where vegetation is still rampant on primeval rocks and new generations of trees are springing up, untouched by man, from the decaying carcases of the old ones; to listen in the still, calm evening air to the humming of the insect world (the most active tenants of these elevated tracts); and to mark, as the daylight wanes, the unnumbered orbs of night stealing one by one on to the wide arch of heaven, as brilliant as they were on the first evening of their birth;—are the lofty enjoyments, which the intellectual mind can grasp in these transcendent heights.

"It is needless however to pursue the picture further, for it is impossible to do justice to what *experience alone* can enable us to appreciate. And let not any one suppose that the varied objects and scenes of novelty which administer to our superior feelings, and charm the eye, in these upland solitudes are adapted only to the scrutiny of a naturalist, and are either beneath the notice of, or else cannot be sufficiently entered into, by the general mass,—for such is by no means the case. A single trial, we are convined, will be more than enough to prove the reverse, provided the adventurer be not altogether insensible to perceptions from without, or incurious as to the workings of the external universe around him. This however, we need scarcely add, is *sine qua non*,—for it has been well said that "he who wondereth at nothing hath no capabilities of bliss; but he that *scrutinizeth trifles* hath a store of pleasure to his hand: and happy and wise is the man to whose mind *a trifle existeth not*."

"The great expense necessarily attending the publication of a work like the present one will be a sufficient guarantee that it has been undertaken purely as a 'labor of love,' and with the sole aim (within its prescribed limits) of arriving at the truth. How far I have succeeded in this is a problem which must be solved by others: meanwhile I appeal boldly to *observation, in situ*, as the test by which I would most desire to be judged,—having but little fear of the experiment, and believing that we are never in so favorable a position for deciding on the relative importance of Zoological differences as when the local circumstances connected with them are taken into account. Where I have overlooked facts, or failed in my conclusions concerning them, I must crave that indulgence which is never denied to the honest inquirer even in a field so small as that throughout which my researches have been prosecuted,—researches which I am well aware can at the best add but an iota to our knowledge,—'A drop dissevered from the boundless sea.'"

The second work discusses a philosophical question in science through the facts the author has gathered in his entomological researches. While having no sympathy with the notion of species rising into higher species, he illustrates the relations of genera as follows, taking the ground that they are realities and have their well defined types or centres while on their borders they may blend with other genera.

"Taking the preceding considerations into account, the question will perhaps arise,—How then is a genus to be defined? To which I may

reply that, were I asked whether genera had a real existence in the animate world, my answer would be that they undoubtedly have,—though not in the sense (which is so commonly supposed) of abrupt and disconnected groups. I conceive them to be gradually formed nuclei, through the gathering together of creatures which more or less resemble each other, around a central type: they are the *dilatations* (to use our late simile) along a chain which is itself composed of separate, though differently shaped links,—the links being the actual species themselves, and the swellings, or nodes, the slowly developed genera into which they naturally fall. When I say "slowly developed," my meaning may possibly require some slight comment. It is simply therefore to guard against the fallacy, which I have so often disclaimed, that genera are abruptly (or suddenly) terminated on their outer limits, that the expression has been employed. Though I believe that a series of *species*, each partially imitating the next in contact with it, is Nature's truest system; yet we must be all of us aware that those species do certainly tend, in the main, to map out assemblages of divers phases and magnitudes, distinguished by peculiar characteristics which the several members of each squadron have more or less in common. So that it is only in the middle points that these various groups, respectively, attain their maximum,—every one of which (by way of illustration) may be described as a *concentric bulb*, which becomes denser, as it were, in its successive component layers, and more typical, as it approaches its core."

The main topic of the work is the variations which species undergo. He illustrates it by facts and urges the importance of its study as the foundation of our knowledge of species. With every species in nature, organic or inorganic, there appears to be a normal type admitting of librations in many of its characters, on either side through external influences; and the complete idea involves a knowledge of the extent and laws of these librations. We cite the following from the author's concluding chapter.

"As regards that most obscure of questions, *what the limits of species really are*, observation alone can decide the point. It frequently happens indeed that even observation itself is insufficient to render the lines of demarcation intelligible,—therefore, how much more mere dialectics!

To attempt to argue such a subject on abstract principles, would be simply absurd; for as Lord Bacon has remarked, the "subtility of Nature far exceeds the subtility of reasoning:" but if, by a careful collation of *facts*, and the sifting of minute particulars gathered from without, the problem be fairly and deliberately surveyed, the various disturbing elements which the creatures have been severally exposed to, having been duly taken into account, the boundaries will not often be difficult to define. Albeit, we must except those races of animals and plants which, through a long course of centuries, have become modified by man,—the starting-points of which will perhaps continue to the last to be shrouded in mystery and doubt. It would be scarcely consistent indeed to weigh tribes which have been thus unnaturally tampered with by the same standard of evidence as we require for those which have remained for ever untouched and free,—especially so, since (as we have already

observed) it does absolutely appear, that those species, the external aspects of which have been thus artificially controlled, are by constitution more tractile (and possess, therefore, more decided powers for aberration,) than the rest. Whether traces of design may be recognized in this circumstance, or whether those forms were originally selected by man *on account of* their pliability, it is not for me to conjecture; nevertheless, the first of these inferences is the one which I should, myself, be *à priori* inclined to subscribe to.

In examining, however, this enigma, *of the limits within which variation is* (as such) *to be recognized*, it should never be forgotten, that it is possible for those boundaries to be absolutely and critically marked out even where we are not able to discern them: so that the difficulty which a few domesticated creatures of a singularly flexible organization present, should not unnecessarily predispose us to dispute the question in its larger and more general bearings. Nor should we be unmindful that (as Sir Charles Lyell has aptly suggested) "some mere varieties present greater differences, *inter se*, than do many individuals of distinct species;" for it is a truth of considerable importance, and one which may help us out of many an apparent dilemma.

But, whatever be the several ranges within which the members of the organic creation are free to vary, we are positively certain that, *unless the definition of a species, as involving relationship, be more than a delusion or romance*, their circumferences are of necessity real, and must be indicated *somewhere*,—as strictly, moreover, and rigidly, as it is possible for anything in Nature to be chalked out. The whole problem, in that case, does in effect resolve itself into this,—Where, and how, are the lines of demarcation to be drawn? No amount of inconstancy, provided its limits be fixed, is irreconcilable with the doctrine of specific similitudes. Like the ever-shifting curves which the white foam of the untiring tide describes upon the shore, races may ebb and flow; but they have their boundaries, in either direction, beyond which they can never pass. And thus in every species we may detect, to a greater or less extent, the emblem of instability and permanence combined: although perceived, when inquired into, to be fickle and fluctuating in their component parts, in their general outline they remain steadfast and unaltered, as of old,—

> "Still changing, yet unchanged; still doom'd to feel
> *Endless mutation, in perpetual rest.*"

5. *On the Fresh water Entomostraca of South America;* by John Lubbock, Esq., F.Z.S., (Trans. Ent. 8vo, iii, N. S., Part vi) —Mr. Lubbock who has taken up the investigation of the Entomostraca with great zeal and success, describes in this paper four new species of Entomostraca from South America, *Cypris australis*, *C. brasiliensis*, *Daphnia brasiliensis*, and *Diaptomus brasiliensis*. They were collected by Charles Darwin, Esq.

IV. ASTRONOMY.

1. *Shooting Stars of August* 10, 1856.—During the night of Friday, August 8th, 1856, the weather at New Haven was stormy. The next night on account of the cloudy state of the sky and other obstacles, no observation for meteors was attempted by us.

On the night of August 10th–11th, observations were commenced by Messrs. Francis Bradley, Charles Tomlinson and myself. Until about half past one o'clock of Monday morning the sky was clear and favorable. From this time onward, clouds interfered more and more, so that by $2^h\ 50^m$ A. M. of the 11th we left the field. During the period of observation, about 3 hours and 45 minutes, we noted *two hundred and eighty three* different shooting stars, as follows:

$11^h\ 5^m$ to midn.,	W. N. W.	21
" "	N. E.	12
" "	S.	14——47
Midn. to 1 A. M. 11th,	W. N. W.	54
" "	N. E.	27
" "	S.	19——100
1 to 2 A. M.,	W. N. W.	31
" "	N. E.	21
" "	S.	21——73
2 to $2\ 50^m$ A. M.	W. N. W.	23
" "	N. E.	24
" "	S.	16——63

In general characteristics these shooting stars resembled those of the August period in former years. The visible paths of a large part of them, if traced back, would meet in the vicinity of the sword-handle of Perseus. Some moved in other directions, and a few appeared to go towards the general radiant. Several of them equalled in brilliancy stars of the first magnitude, and left sparkling trains behind them.

The present being leap-year, it is probable that the meteors were more numerous on the night of the 9th–10th, than on the night succeeding.

E. C. Herrick.

2. *Astronomical Observatory at the University of Mississippi*, (from a letter to the editors dated, University of Mississippi, Oxford, July 19, 1856.)—I think it may interest the scientific world to know, that the Board of Trustees of this University have sanctioned the erection of an Astronomical Observatory at this place, and have authorized a contract for a transit circle similar to that introduced by Mr. Airy at Greenwich. Other instruments will be supplied hereafter. The building provides for a first-class equatorial telescope.

On the completion of the circle, regular observations will be instituted and constantly sustained here. An astronomer will be employed, with no other business but to observe.

It is hoped that Mississippi will now make a beginning—the first earnest beginning in the Southern States—to contribute effectually to the

progress of the noblest of sciences; and it is also hoped that this institution may be the means of awakening to activity, and leading on to its full development, that native talent in southern youth, which, when it now appears, too often relapses into inaction, for the want of a field for its exercise.

The principle which the Board of Trustees of this University have distinctly recognised, as that which is to govern all their future policy in building up this institution, is that they will employ all their resources as fast as they become available, in adding to the means and appliances accumulated here for acquiring or imparting knowledge in all its departments; and that, since the means will not probably be wanting to make the institution equal in all visible respects to the best on the continent, they will not be content to see it occupy, in any particular, an inferior position.

They are therefore making steady and large appropriations for the increase of the library, for additions to the stock of philosophical and chemical apparatus, for minerals, shells, &c., &c., all of which are rapidly giving to the University the aspect of an institution of long standing.

The earnest desire of the Board is also to encourage here a spirit of original investigation, by putting the means of research into the hands of their officers, and it can hardly be doubted that when the arrangements shall have been carried out, which this enlightened policy has suggested, (which will be within two or three years,) Mississippi, through her University, will place herself in a very honorable relation to the progress of intellectual improvement in the world. B.

V. MISCELLANEOUS INTELLIGENCE.

1. *Observations on the climates of California;* by Mr. George Bartlett, (from a letter dated, Providence, June 27, 1856.)—The natural forces which produce the various meteorological phenomena of California, are much less numerous than in the eastern part of the continent, and act on a much larger scale, and they are therefore more easily understood. In fact, with a knowledge of three great causes, the peculiarities of the several climates of California would have been readily anticipated. These are; 1st, the cold ocean current which rolls along the coast from northwest to southeast; 2d, the direction of the winds; 3d, that property of air by which its capacity for containing moisture is increased with the elevation of its temperature. The ocean current will no doubt be thoroughly examined in the course of the Coast Survey. Dr. Gibbons, of San Francisco, ascertained at one time its temperature to be 54° Fahrenheit.

Now, during the summer months, as soon as the rays of the sun have warmed the air over the land, it becomes rarified, and the colder and heavier air rushes in under it from the ocean, producing that sea-breeze, which lashes the coast of California with so remarkable regularity, almost every afternoon throughout the summer months, driving the sand through the air, and compelling people to put on over-coats and kindle fires, even under that cloudless sky and in those low latitudes. As this cold air, from the ocean is warmed by the land, of course its capacity for holding moisture is increased, and instead of there being any tendency to

form clouds and to rain, it becomes a very drying air, absorbing water from everything that it touches. This is the very simple and plain explanation of the dry season.

The most wonderful phenomenon of the California climates, is the marked manner in which they are cut in two by no higher chain of mountains than the Coast Range. This range extends along the coast of California from latitude 34½ to 41½, and is so low, that snow collects during the winter only on a few of the highest peaks. Now, while the western side of this range has the cold summer above described, the valley on the east side is one of the hottest portions of the earth. This valley, through which flow, in opposite directions, the waters of the Sacramento and the San Joaquin, extends about 400 miles from north to south, with an average breadth of perhaps 60 miles, from the Coast Range on the west to the Sierra Nevada on the east. It is a very flat valley, much more level than the western prairies, and occupies the great portion of the interior of California. It has been quite difficult to obtain exposures of a thermometer which were unobjectional. In the cloth tents and stores which were in use in 1849 and '50, the temperature would range in the warm days from 115° to 120°. On the north side of a large tree, also in a wooden cabin covered with earth, a friend of the writer observed the mercury at 110° and 112° during many of the days of 1850. On the north side of a large two-story frame house, with but one other house near, and that one several rods distant, the writer has observed the mercury at 109°. But Dr. Haille at Marysville, by hanging his thermometer in a draft of air in the back part of his office, where it was shaded by high buildings around, succeeded in keeping the mercury down to 102° during the summer of 1852. The sun rises clear in the east, rolls up over the heads of the inhabitants, drying and scorching everything in sight, and sinks into the west—"One unclouded blaze of living light." And this is repeated day after day, and month after month. The hottest time of day is about half-past five in the afternoon. The nights are cool; you need two or three blankets to sleep comfortably even in the hottest part of the summer. A plate of butter set in a common wooden house, will be perfectly liquid at night, and entirely hard in the morning, and these changes will occur every twenty-four hours for months in succession.

The change from the cold climate of the coast to the heat of the valley is marvellous. You go on board a steamboat at San Francisco at four o'clock in the afternoon, and find the passengers, all dressed in winter clothing, flannels and overcoats, huddled around the stove in the cabin with its hot anthracite fire. The next morning at sun-rise, you find yourself going up the Sacramento river, and, as your state-room is insufferably hot, you put on the thinnest summer clothing, and go out on the guards of the boat, oppressed with the heat, and the perspiration starting from your pores.

There seems to be some doubt whether the great difference between the climate of the coast and that of the interior, is to be wholly attributed to the Coast Range. From Benicia this range trends inland, leaving quite a broad tract between it and the sea. On the east side of the bay of San Francisco, between the bay and the mountains, is a tract of level land,

five to ten miles in width, of great fertility and which, in the month of May, is almost one unbroken field of waving grain. This plain is swept every afternoon in summer by the sea-breeze, and there is no doubt the breeze here is less violent and less cold than it is in San Francisco, though nothing intervenes but a smooth sheet of water.

This plain may be considered a portion of the valley of San Josè, which extends southerly from the neighborhood of San Francisco, some 70 or 80 miles, between the broken hills of the coast and the main ridge of the Coast Range. This valley, as well as others similarly situated, among the straggling ridges of the Coast Range, such as Nappa, Santa Cruz, San Pablo, &c., enjoys the most delightful climate in the world. The fierce gale which drives through the streets of San Francisco, is here tempered into a bland and bracing breeze. The malaria, so prevalent in the great valley of the interior, is here unknown. The husbandman reaps the abundant harvests of the fertile soil in *health* and *comfort*. For two months he reaps, leaving the grain in the field, and for two months more he threshes and winnows, allowing the bags of grain to stand where they are filled, without the slightest apprehension of a shower. No thunder ever disturbs the serenity of the sky. These delicious valleys are indeed the Edens of the west.

Besides these three climates in California, that of the coast, that of the interior, and that of the small valleys which lie among the scattered branches of the Coast Range, there is yet a fourth, the climate of the mountains. But this, with the exception of its dry season, has merely the characteristics of other mountain climates, the heat decreasing with the altitude.

These are the summer climates. In the winter there is no perceptible difference in the weather throughout California, except the very small difference caused by the latitude, and the very great difference caused by the altitude. In the lowlands the climate is very similar to April in New England, or perhaps, it may be more nearly compared to our spring, from the middle of March to the middle of May. There is no snow, though frosts are frequent. Near San Francisco, peas are planted in October, and strawberries are to be had every day in the year. Still, ice has been known to form half an inch thick in a night. On the mountains, snow falls to a great depth. Indeed, the stories which are told of its depth are incredible, many persons having assured the writer that it would average ten feet. Nearly all the rains are with the wind from the south, probably caused by the simple cooling of the air in moving from a lower to a higher latitude. Occasionally, about once in a season, there is a rain with the wind from the north. The climate is remarkably serene. There are very few gales or high winds. In the winter it is generally calm. In the summer, in the interior, there is generally a very mild breeze, more than half of the time from the south ; and, very unaccountably, the wind from this direction is generally cooler than the wind from the northwest. Probably the reason why there is no thunder and lightning, or so little, is, that there are no showers or clouds in the summer. That the sea breeze, with its accompanying dryness, does not continue through the winter, is probably attributable to the diminished force of the sun's rays in his withdrawal to the south.

2. *Apparatus for taking specific gravity;* by Messrs. Eckfeldt and Dubois, (Proc. Amer. Phil. Soc., vi, 193.)—The apparatus for taking specific gravity of solids, is essentially a tin cup with a spout at the side. Five vessels are here shown, of different sizes and shapes, to suit different cases. Four of these are cylindrical, ranging from six to ten inches high, and from two to five inches in diameter. The tall one (ten inches by two) is intended for the trial of silver spoons and forks, or articles of similar shape; the others are adapted to lumps of stone or metal, or blocks of wood, of various sizes. The fifth vessel is rectangular, measuring $6\frac{1}{2}$ inches high, $1\frac{3}{4}$ inches long, and $\frac{1}{4}$ inch broad, being intended for coins, not smaller than the half eagle or quarter dollar, and for small medals and gems of admissible size. This vessel is provided with a brass plate, as a *plunger*, for diminishing the surface. The smaller vessels are set firmly in mahogany blocks, to insure steadiness in the operation; and these blocks have screw feet, for convenience of levelling. The spouts extend upward, with a curve outward, the beak being far enough below the top of the cup to allow for the space to be taken up by the specimen, that it may not force the water over the top nor leave any point uncovered by water. The aperture of the spout is tapered to the one-sixteenth of an inch, and a small bit of wire projects downwards from the beak, to carry the drops of water properly. A small cup is placed directly under, to catch the water displaced, and a brass weight, equal to the weight of this cup when empty, is found convenient (though not necessary) as a counter-weight.

When the operation is to be performed, suppose upon a gold or silver ore, the ore is first weighed, and afterwards its surface is moistened. The vessel is then nearly filled with water, and so much as is superfluous, or above the level of the beak of the spout, runs or drips off, to a final drop. The small cup is then set under the beak, and the lump is carefully lowered into the vessel by a hair wire or waxed thread. This, of course, displaces its own bulk of water, which runs off into the small cup, gradually coming back to the former level, by a final drop. The weight of this water is the divisor, the weight of the lump the dividend, and the quotient is the specific gravity.

In connection with this apparatus, the following miscellaneous remarks are offered to the Society.

The opening of the gold mines of California brought out a great number of beautiful specimens of gold in the matrix (or mingled with quartz) of the most fanciful forms, and every variety of size and value. In many cases it was presumed, by the holders of these prizes, that they would bring more money, as curiosities, than as bullion; and at any rate, very many owners were unwilling to have such attractive specimens spoiled until they had been sufficiently exhibited. At the same time, it was always desirable to know, pretty nearly, how much gold was actually contained; and, to obtain such estimates, upon what was supposed to be reliable authority, many of these specimens were brought to the assay office of the mint. They came at a time when we were overpowered with the legitimate business of the office, and yet it seemed impossible to refuse such requests; and, for a considerable time, such employment was interesting as a matter of scientific inquiry. Especially when we could compare our estimates with the more definite and accurate re-

sults obtained by putting specimens or "nuggets" through the regular routine of melting and assay. On one occasion a lump, weighing over 200 pounds, came to us for this purpose. It was sent by the Isthmus route, at a time when transportation was enormously dear, and having visible gold on the surface, was expected to be rich throughout the mass; and, with this expectation, was on the way to London, to make an impression upon the stock market there. By the aids of a very large steelyard beam and copper kettle, we were enabled to take the specific gravity, but could not make it higher than that of compact quartz. The result seemed so questionable, that we obtained permission to break up the rock, and found that what little gold it contained was at the surface.

Not only were ores brought to us from California, to be estimated, but also from other mining regions, and of various metals; but chiefly gold and silver. As the specimens were of all sizes, these demands upon us often proved embarrassing, since it was necessary to have beams suited to them, and with attachments for weighing in water. We therefore had frequent recourse to the method advised by the elder Dr. Patterson (formerly President of this Society), which consisted in using a jar or pitcher, rather larger than the specimen, and not over-large at the mouth; this was filled with water up to a marked line; and then, by introducing the specimen, and bringing back the water to the same line, so much water was removed as was just equal in bulk to the bulk of the specimen; the weight of this water gave the divisor, the weight of the specimen (taken while dry), the dividend, and the quotient was the specific gravity.

The results thus obtained were, generally, as satisfactory as those by the usual method. And here it may be interesting to cite a few examples from our minutes, of specimens estimated by one or other of the processes mentioned, and afterwards melted down and assayed as regular deposits.

1. A lump of quartz, containing gold, found by two Mexicans of the "Sonorian camp," in California, weighed $265\frac{1}{2}$ ounces: assuming the quartz at the sp. gr. of 2·60, the amount of gold appeared by sp. gr. of the lump, to be $209\frac{1}{2}$ ounces; the actual amount was $211\frac{1}{8}$ ounces.—2. Another lump, where we assumed the matrix at 2·64, gave an estimate of $100\frac{1}{8}$ ounces of gold; the actual product was $100\frac{1}{10}$ ounces.—3. Four pebbles taken together, estimated at 77 ounces; actual content $76\frac{8}{10}$ ounces.—And, lastly, a lump which had been bought in California for 800 dollars, and which weighed $408\frac{1}{2}$ ounces, gave an estimate of $89\frac{1}{2}$ ounces, or 1572 dollars, taking the matrix at 2·63; the actual yield was $91\frac{2}{10}$ ounces, or 1602 dollars; the fineness being 850 thousandths. In this case there was an error of 30 dollars, or about two per cent. upon the value; an amount of error to which such specimens are liable, with any apparatus.

But it was obvious that the method of displacement required a series of vessels specially adapted to the operation, to compete with weighing in closeness of results. After a good deal of reflection and experimenting, in which many modifications of shape and arrangement were tried and discarded, and which it would be cumbersome to notice in this place, the apparatus now shown was found to answer best. In practice it is really a pleasant and satisfactory substitute for the tedious and irk-

some method usually resorted to. Some few precautions must, of course, be attended to. The vessel must stand firmly. If at first the water will not flow, or flows fitfully, the obstruction will be removed by blowing a little in the spout.

An investigation of some interest, growing out of this matter, may properly be noticed. Where we are operating on substances of low specific gravity, say wood or stone, a drop or two of water, or the size of the drop, in tapering off the divisor, is of no consequence. But it is otherwise in the case of a gold coin, for example:—in a double eagle, the difference of one drop of water (ordinarily about a half-grain) in the divisor, would affect the result to the extent of 0·3, which, carried into the fineness, would make a difference of 15 or 20 thousandths; and in the case of a half-eagle, the uncertainty of result would be proportionally increased. The question then arose, what fluid, or what modification of water, will afford us a smaller drop? for, as was just observed, a half-grain is, on the average, the smallest of clean water that will detach itself by its own weight. Very much depends, of course, upon the size of the aperture, in the measure of drops of fluid; one drop of water from a large beak weighed $1\frac{1}{8}$ grains. In the Dispensatory of Drs. Wood and Bache, there is a table of the experimental results of Mr. Durand, showing the number of drops of different liquids equivalent to a fluidrachm (page 1405). The differences are very remarkable; distilled water, for instance, being set down at 45 drops, and pure alcohol at 138 drops. And in our own experiments, the drop of alcohol was about one-third the weight of the drop of water, from the same pipette. This seemed to point to alcohol as a substitute; but there were obvious objections, and a much better vehicle was found in *soapy water*.

The best white soap, sold at the shops, is of the same specific gravity as water, and its mixture with water makes no change, in that respect. When the mixture is as strong as children use for blowing bubbles (we cannot conveniently give this measure in figures), the cohesion or tenacity of the water is so much weakened that the drop is reduced to one-tenth of a grain. No other fluid makes so small a drop as this. And there is the further advantage, that soapy water, though excellent for making bubbles, is less liable to retain them below the surface than pure water. So small a drop, of course, makes the experiment more tedious, and, by using less soap, the size of the drop will be, in many cases, advantageously increased. * * * * *

3. *Discovery of Palæozoic Fossils in Eastern Massachusetts;* by Prof. W. B. Rogers, (from a letter to J. D. Dana, dated Boston, August 13, 1856.)*—You will, I am sure, be surprised as well as pleased by the news I am about to tell you. You are aware that the altered slates and grits which show themselves interruptedly throughout a good part of Eastern Massachusetts, have with the exception of the coal measures on the confines of this State and Rhode Island, failed hitherto to furnish geologists with any fossil evidences of a Palæozoic age, although from aspect and position they have been *conjecturally* classed with the system of rocks belonging to this period. Indeed the highly altered condition of these beds generally, traceable no doubt to the great masses of syenite and other igneous materials by which they are traversed or enclosed,

* This important paper was received too late for insertion under Geology.

would naturally forbid the expectation of finding in these any distinguishable fossil forms.

Lately, through the kindness of Peter Wainwright, Esq., of this city, I have been led to examine a quarry in the belt of silicious and argillaceous slate which lies on the boundary of Quincy and Braintree, about ten miles south of Boston, and to my great surprise and delight I found it to be a *locality of Trilobites.*

It appears that for several years past the owner of the quarry, Mr. E. Hayward and his family, have been aware of the existence of these so-called images in the rock, which from time to time they have quarried as ballasting material for wharves, but until now the locality has remained entirely unknown to science.

The fossils are in the form of casts, some of them of great size and lying at various levels in the strata. So far as I have yet explored the rock, they belong chiefly if not altogether to one species, which on the authority of Agassiz, as well as my own comparison with Barrande's description and figures, is undoubtedly a *Paradoxides.* Of its specific affinities I will not now speak, further than to remark that the specimens agree more closely with Barrande's *P. spinosus* than with any other form.

As the genus Paradoxides is peculiar to the lowest of the Palæozoic rocks in Bohemia, Sweden, and Great Britain, marking the Primordial division of Barrande and the Lingular flags of the British Survey, we will probably be called upon to place the fossil belt of Quincy and Braintree on or near the horizon of our lowest fossiliferous group, that is to say, somewhere about the level of the Primal rocks, the Potsdam sandstone, and the Protozoic sandstone of Owen, containing Dikelocephalus in Wisconsin and Minnesota. *Thus, for the first time are we furnished with the data for establishing conclusively the Geological age of any portion of this part of ancient and highly altered sandstones, and what gives further interest to the discovery, for defining in regard to this region the very base of the Palæozoic column as recognized in other parts of the globe.*

The newly discovered fossil is, I am satisfied, identical with the *Par. Harlani* described by Green in his monograph of N. American Trilobites, from a specimen of *unknown locality* procured through Dr. Harlan from Mr. Alger some twenty-five years ago. I draw this conclusion from the close agreement of a nearly complete specimen of the Quincy Trilobite with the cast of P. Harlani and from the identity of the rock as described by Green, and at once recognised by Mr. Alger's experienced eye on seeing my collection of Quincy specimens.

In this connection I find in Barrande a remark which, at the same time that it is historically curious, has an interesting bearing on the specific affinities of our fossil. He observes, "We see in different collections, especially in that of the School of Mines and the British Museum, under the name of Paradoxides Harlani, from the United States, a cast of a Trilobite, which appears to us to be identical with P. spinosus of great size, such as found at Skrey in Bohemia."

It thus appears that the vagrant Par. Harlani, so long an obscure exile has at last been restored to its native seat, to take a conspicuous place in the most ancient dynasty of living forms belonging to the geology of New England.

The interest of this discovery of a locality of Paradoxides in our neighborhood is not a little heightened, by the circumstance of its being the only instance, as I believe, in which forms of this genus have been found anywhere on the continent. Barrande after speaking of its restriction to Protozoic strata in Bohemia, Sweden, Wales, &c., has the following observations on this subject: "The presence of Paradoxides has not been satisfactorily proved in any other Silurian region, although this generic name has been applied to North American forms, P. Boltoni and P. Harlani. The first of these is known to be a Lichas and *we know nothing of the other*. The care with which Hall has described the Trilobites of the Lower Silurian rocks of the country in question is sufficient proof that he had not discovered any trace of Paradoxides at the time of publishing the first volume of the Palæontology of N. Y." I may add to this, that in no subsequent publication have I seen any reference to the finding of fossils of this genus in the rocks of this continent.

The occurrence of well preserved fossils among rocks so highly altered and so contiguous to great igneous masses as are the fossiliferous slates of Quincy, may well encourage us to make careful search in other parts of Eastern New England, where heretofore such an exploration would have been deemed useless. Although we cannot hope to build up the geological column of New England from the Protozoic base just established to the carboniferous rocks, supposing all the intervening formations to be represented in this region, we may at least succeed in determining by fossils hereafter discovered some of the principal stages in its structure, and thus relate its strata definitely to the great Palæozoic divisions of our Appalachian Geology.

4. *Hailstorm in Guilford County, N. C.*—On the 9th of June, 1856, a hailstorm of unusual violence passed over a portion of Guilford County, N. C. An observer at Hillsdale in that county, gives the following description. "The cloud came up from the SW about 12. The storm began with rain, thunder and lightning. In a few minutes hailstones of great size began to fall, dashing in exposed windows, and splitting the shingles on the roof of the building in which I was. The rain continued an hour after the hail ceased. As soon as it was safe to go out, some of the hailstones were brought in. One measured eight inches in circumference, and I concluded it must have been nine or ten when it fell, as there had been so much rain and that a very warm one. The weather was very hot, and there was no change of temperature during the week following. This hailstone was a perfect globe. Others measured as large in one direction, but they were flat."

"The grounds around us were so completely covered with leaves and boughs of trees from the oak grove in which we were, that we had little chance to know what actually fell about us. A mile westward the storm was still more severe. The trees have a strong appearance of winter, and fields of wheat have been turned over to the use of cattle. There was destruction of windows and of small animals, and a few wayfarers were severely beaten. The storm extended about fifteen miles in one direction and five or six in the other. The hail fell in *lines*, a field here and a garden there being destroyed, while intermediate ones were left uninjured. The hail had a strong flavor of turpentine. This is the testimony of persons testing it at different and distant localities."

5. *Monks Island or Colombian Guano;* by Dr. A. S. Piggot, (Proc. Amer. Phil. Soc., Philad. vi, 189).—In the spring of 1855, there was brought into the port of Baltimore a hard, rocky substance, which was offered for sale under the name of Colombian Guano. At first, there was a great effort made to involve in mystery the whole history of the article, its locality being carefully kept secret. Gradually, however, it became known that it was found on Los Monges, a collection of keys at the entrance of the Gulf of Maracaibo. It has also been found on El Roncador, off the Musquito coast, on Aves and various other keys of the Caribbean Sea. On Los Monges, it forms, as the captains who procured it say, a thin polished crust over the entire surface. Below this crust lies the common Mexican guano. In some instances, however, this same smooth incrustation covers thinly the jutting points of primitive and metamorphic rocks. I have before me a splinter of rock of this kind, crested with an inch-thick deposit of this guano; and I have seen many in which the white crust formed a thin lamina over the surface. Many such were brought in, in the first cargo, which will account for the large amount of sand in the subjoined analysis. Only the ground guano was thus sent to me, so that the analysis represents the commercial article, not a selected specimen. The actual guano contains only about 0·5 per cent of siliceous matter.

The unusual quantity of phosphoric acid, contained in this substance, attracted attention, and many analyses were made of the new guano. The habit of calculating the phosphates in these Mexican guanos, as bone earth, or tribasic phosphate of lime, led some chemists into grievous errors. The new material was, in one breath, called a superphosphate of lime, and in another, said to contain from seven to eleven per cent of *free phosphoric acid*. In common with other chemists of Baltimore, on the first importation of this guano, I made an analysis of it, and found it to contain a large proportion of phosphates, but expressed no opinion as to their composition. At last, however, hearing so much said about the soluble phosphoric acid in this substance, I examined it more carefully, and found but little of this acid soluble in water, and none of it *free*. I obtained the following results:

Phosphoric acid,	41·62
Sulphuric acid,	3·65
Chlorine,	0·5
Lime,	33·83
Magnesia,	3·27
Iron,	trace.
Fluorine,	trace.
Sand (consisting chiefly of primitive rocks in powder,)	5·34
Water (hygrometric,)	2·15
Organic matter, salts of ammonia (containing 0·23 of ammonia) and combined water,	8·62
Loss, in which are the alkalies (not estimated,)	1·47
	100·00

The proportions of the phosphates vary in different samples. Thus, in one specimen, recently examined, there was a very small proportion of magnesia and 4·23 per cent of phosphate of iron.

The organic matter was partly soluble in hydrochloric acid, and partly in potash. A cursory examination of it seemed to indicate that it consisted chiefly of humus and the acids of the crenic group.

From this analysis I thought myself justified in announcing that the lime and magnesia in the compound under consideration are combined with the phosphoric acid so as to form a tribasic salt, in which one atom of water substitutes one atom of alkaline earth, according to the formula $2MO, HO, PO_5$. A subsequent examination and recalculation of my results has convinced me that the announcement was somewhat premature, and that the analysis would not fully bear the construction put upon it. I have, however, never changed the opinion then advanced, as the discrepancies are slight and easily accounted for.

The statement of my views led to further investigation. Among others, Dr. Campbell Morfit examined the substance, and came to a different conclusion from that at which I had arrived. Drs. Higgins and Bickell, Chief and Assistant State Chemists of Maryland, shortly after published a paper in which they agreed with me in the main. Their analysis was more elaborate than mine, and comprised two distinct examinations; one of the white, polished crust, the other of the body of the rock. Without going into minutiæ, I will simply state that they found the exterior layer to contain phosphates of lime and magnesia, of the formula $3MO\ PO_5$, while, in the body of the rock, the salts were composed, as I had previously announced. They also ascertained that in the outer layer the sulphuric acid was combined with soda, while in the body of the rock it was united to lime.

6. *On the Monks Island Guano;* by Dr. A. A. Hayes (Proc. Boston Soc. Nat. Hist., v, 349).—Dr. Hayes first describes the general characters of the hardened guano, mentioning its rounded nodular surface, its hardness as above that of fluor, and its specific gravity as averaging 2·440. He states that the arenaceous variety consists of grains about as large as mustard seed, and that this granular structure is entirely lost as it passes into the solidified guano, which forms a crust or layer over it. The two kinds differ not very much in composition. After giving the results of analyses and pointing out the existence of a very large percentage of bone, phosphate of lime, and magnesia, he argues that the guano has been formed mainly from fish-bones. With regard to the change in consolidation he observes.

"Recurring to the composition of guano-rock, we see that the proportion of organic salts and other organic matter, is much larger than exists in the guano from which it is derived. The physical characters of the rock are modified by the presence of these compounds, but the most remarkable change is that from a granular to a compact solid. This change could be effected by infiltration, as takes place from calcareous waters; but as the rock guano is above the mass producing the soluble organic salts, it is necessary to consider another condition.

"When water holding saline matter in solution evaporates from the surface of the earth, pure water alone escapes, while the saline and colored organic compounds remain at or near the surface. In accordance with this law, the saline matters which can be dissolved, and the colored matters which can be suspended, in water, rise to the surface, and so long as capillarity can act, they are deposited in the porous parts, grad-

ually filling the pores and consolidating the surface. Doubtless, while this process is proceeding, rains carry back a part, which is to be raised anew, until finally the surface-rock, no longer pervious, becomes cemented into the compact state it now presents, by this action of capillarity."

7. *Neo-Macropia.*—In vol. viii, p. 442, 2nd Series of this Journal, I gave a brief notice of this kind of abnormal vision. Since that time, 1849, I have found many other cases. Dr. DeForest of the Syrian Mission describes to me a marked instance of it in a native girl belonging to the mission at Beirut. A striking instance in this city is now before me, a boy near fourteen years old. He never saw objects distinctly, till he happened to put on the spectacles used by his grandfather. He now uses constantly the convex glasses suited to ordinary eyes of persons eighty years of age. Indeed the focus is much too short for my old eyes, as his glasses have the principal focus less than six inches, while mine is fourteen inches. Without glasses he can see very little, and with them at all distances distinctly. C. D.

8. *Artificial light for taking photographs.*—A very brilliant light has been produced by directing a stream of oxygen gas into the flame of coal gas which had been previously made to pass through cotton and naphtha in order to surcharge it with carbon. With this light, using a reflector, a photograph of an engraving could be taken by the camera in a very short time.—Roy. Cornw. Polytech. Soc. 1855, xli.

9. *Waters of the Dead Sea.*—Analysis by F. Moldenhauer (Ann. Ch. u. Pharm., xcvii, 357): Solid portion 13·6111 per cent; composition: chlorid of potassium 2·3910, chlorid of sodium 2·9575, chlorid of magnesium 6·8121, chlorid of calcium 1·4719, bromid of magnesium 0·1838, sulphate of potash, 0·0627 = 13·8790. Specific gravity 1·1160. The water was collected in June of 1854.

10. *Density of the Waters of the Caspian Sea;* by A. Moritz.—Mr. Moritz visited the Southwest coast of the Caspian in the summer of 1850, and obtained the following determinations of the density.—At Derbent, 1·00524, at 22° R.; at Baku, 1·00616 at 22·1° R., and 1·00976 at 8·1° R.; at Persien, 1·00583, at 22·6° R.—Bullet. St. Petersb. Phys. Math., xiv, 162–168.

11. *Well in the Desert of Sahara.*—A well sunk at Tamerna in the Sahara to a depth of 66 yards, gave on the 9th of June last a jet or flow of water amounting to 3600 litres per minute.

12. *Composition of the Water of the Delaware River;* by Henry Wurtz.—The water analyzed by Mr. Wurtz, as cited in this volume, page 124, was taken from the Delaware River at Trenton, New Jersey.

13. *Aluminium.*—A watch whose works were made of aluminium was on exhibition at the Paris Exhibition.

14. *Officers of the Academy of Science of St. Louis, for* 1856.—President, George Engelmann, M.D.; 1st Vice President, Hiram A. Prout, M.D.; 2nd Vice President, Nathaniel Holmes; Secretaries. Benj. F. Shumard, M.D., Wm. H. Tingley, M.D.; Treasurer, J. B. Eads.

15. Obituary.—*Professor John Locke.*—Professor Locke of Cincinnati, died on Thursday the 10th of July last, at the age of 65. He had long been distinguished for his zeal and successful labors in many departments of science. His papers in this Journal treat of topics connected with galvanism and electro-magnetism, in which he invented some new pieces

of apparatus, geology and palæontology, the earth's magnetism, and the invention of the Electro-chronograph, which he claimed the honor of, against one or two rivals. On the subject of the earth's magnetism he extended much our knowledge, by his explorations over the regions of the Northern Mississippi and Lake Superior. As a writer in Cincinnati observes, "he was an ardent student, a profound scholar, an indefatigable explorer into the causes of things, and a man of pure reputation, of genial nature, and of all the virtues that adorn private life."

16. *Manual of Coal and its Topography*, illustrated by original drawings chiefly of facts in the Geology of the Appalachian Region of the United States of North America; by J. P. LESLEY, Topographical Geologist. 224 pp. 12mo. Philadelphia, 1856.

The scope of this work is hardly indicated in the title. It does not take up the subject of coal in its economical bearings, but rather in its lithological and topographical relations, as illustrated in the Appalachian Regions, especially in Pennsylvania. Neither is it restricted to the subject of Coal, but enters freely into the general topics of mountain structures and forms, the origin of mountains, formation of valleys, theory of drift, topographical drawing, and directions to geological and topographical surveyors, yet mainly from an Appalachian point of view. The author was formerly an assistant in the Geological survey of Pennsylvania, under Prof. H. D. Rogers. He has been an attentive observer, embodies much that is new in his works, and writes with the earnestness of a zealous investigator and thinker, and the positiveness of one who believes that he has the truth, although sometimes assuming more, we think, than the subject or facts will authorize. The illustrations are original and generally excellent. The volume is dedicated to James D. Whelpley and Andrew A. Henderson, who were once assistants in the Pennsylvania Geological survey.

The point in the volume that will excite most remark, is the claim advanced in behalf of Mr. Whelpley and Mr. Henderson, of having first unraveled the Appalachian mountain system. Professor H. D. Rogers published his views on the subject at considerable length in the Transactions of the Geological Association of 1842, having presented them to the Association at the meeting in that year. Mr. Lesley makes no allusion to the paper of Prof. Rogers, and does not mention his name in connection with the subject. "Years of patient toil," he says, "it cost *us* to unfold the mysteries of the Pennsylvanian and Virginian range," including himself with the two persons just mentioned. These gentlemen had been assistants of Prof. Rogers previous to the publication of that paper, and the facts which they observed, were then collected. To substantiate such a claim it is necessary to prove that Prof. Rogers was dependent on the suggestions of these gentlemen for the theory he has advanced, and as preliminary, to settle the legitimate relations between an assistant and the superintendent in a Geological survey.

17. *A Treatise on Land Surveying;* comprising the Theory developed from Five Elementary Principles, and the Practice with the Chain alone, the Compass, the Transit, the Theodolite, the Plane-table, etc. Illustrated with 400 engravings and a Magnetic Chart; by W. M. GILLESPIE, A.M., Civ. Eng., Professor of Civil Engineering in Union College. New York: D. Appleton & Co.—This treatise bears abundant evidence in its whole

structure, that it is the work of one who understands well both the practice and theory of his art. It unites great simplicity of illustration and an exuberance of practical detail, with a clear exhibition of scientific principles. Full directions are given as to the various operations in the field, the uses of instruments, the methods of measurement, calculation, platting and mapping; and at the same time, demonstrations are freely supplied, so that the faithful student will come forth intelligent as well as skilful. The volume contains a chapter on the Government system of surveying the public lands; also Traverse Tables, a Table of chords, of sines and cosines, and of tangents and cotangents; and a map of the United States showing the magnetic variation, displaying to the eye a subject of great importance to the Surveyor.

18. *Annals of the Astronomical Observatory of Harvard College.* Vol. I, Part I. cxci pages, 4to. Cambridge, 1856.—The Cambridge Observatory, through funds resulting from the will of Josiah Quincy, Jr., has commenced the printing of its Annals; and the title-page justly bears tribute to the memory of that Revolutionary patriot. The Observatory is situated in the midst of a generous community, and already the contributions to it, from different sources have amounted to more than 150,000 dollars, of which sum, 100,000 dollars were bequeathed by Edward Bromfield Phillips, 10,600 the gift of David Sears, Esq., and 10,000 through the will of Mr. Quincy. This *first* part of the opening volume is appropriately occupied with a History and Description of the Astronomical Observatory, illustrated by wood-cuts, by William Cranch Bond, A. M., Director of the Observatory. Among the topics, the description and figures of the Electro-recording apparatus are of special interest and importance. The *second* part which was issued last year, comprises a catalogue of fundamental stars, and of five thousand five hundred stars down to the eleventh magnitude, with some of the twelfth magnitude situated between the parallels of 0° and 0° 20′ of north declination.

19. *Manual of Blowpipe Analysis*, for the use of Students; by William Elderhorst, Prof. Chem. in the Rensselaer Polytechnic Institute. 78 pp. 12mo, New York, 1856, G. P. Putnam & Co.—The student in Mineralogy will find this a convenient and useful manual. It takes up the subject in a clear and systematic manner, describing the apparatus and reagents, and modes of blowpipe analysis, and giving briefly the reactions of the principal elements, and of the more common ores of the metals. There are also tables of reactions to facilitate further the blowpipe analysis of minerals.

J. W. Foster: *Report on the Mineral Resources of the Illinois Central Railroad*, made at the request of the President. March 4th, 1856. 30 pp. 8vo, with a plate of sections illustrating the coal fields of Southern Illinois. New York, 1856.

Agricultural Progress, considered with special reference to New Brunswick. Printed by the New Brunswick Society for the Encouragement of Agriculture, Home Manufactures and Commerce. 64 pp. 8vo, 1856.

J. Barnard Davis and J. Thurnam: *Crania Britannica:* Delineations and Descriptions of the Skulls of the early inhabitants of the British Islands, together with notices of their other remains. Decade I, fol. 76 pp. with 12 plates, and wood-cuts in the text. London, 1856.

W. Smith: *A Synopsis of the British Diatomaceæ*, with remarks on their structure. 2 vols. roy. 8vo. London, 1856.

P. Delamotte: *The Practice of Photography:* a Manual for students and amateurs, with a Calotype Frontispiece. 3d edit. revised. 12mo. London, 1856.

R. Howlett: *On the various methods of printing photographic pictures on paper*, with suggestions for their preservation. 12mo. London, 1856.

A. Erman: *Einige Beobachtungen über die Kreideformation an der Nordküste von Spanien.* 16 pp. 8vo, with a plate of fossils; from the Zeitschr. d. deutschen geol. Gesellschaft, 1854.

R. Wolf: *Ueber den Ozongehalt der Luft und seinen Zusammenhang mit der Mortalitat*, with a plate. Bern. Mitheil. March, 1855.

E. d'Eichwald: *Lethæa Rossica, or, Palæontology of Russia.* 8vo. Stuttgart. IVth number, Flora of the Palæozoic, 17¼ leaves, 268 pp. with 23 lithogr. plates, 4to.

H. Bach: *Geognostiche Uebersichtskarte von Deutschland, der Schweiz, und den angrenzenden Ländertheilen.* General Geological Chart of Germany, Switzerland and the adjoining countries, after the large maps of E. de Billy, L. v. Buch, E. de Beaumont, B. Cotta, etc., and additional observations. 9 lithochr. charts in folio with 15 pages of text. Gotha, 1855.

H. Burmeister: *Systematische Uebersicht der Thiere Brasiliens.* 2 Thl. Vogel. Hft 3. Berlin, 1856. 8vo, pp. 321—426.

J. F. J. Schmidt: *Das Zodiacallicht.* Uebersicht der seitherigen Forschungen nebst neuen Beobachtungen über die Erscheinung in den Jahren 1843–1855. 8vo. 111 pp. Braunschweig.

H. v. Sydow: *Oro-hydrographischer Atlas.* 25 Boden- und Gewässer-Karten über alle Theile der Erde. Folio. Gotha.

D'Archiac: *Histoire des Progrès de la Geologie de* 1834 à 1855. Volume VI. of this most valuable work has recently been issued. It takes up the first part of the Jurassic formation.—Price for the volume at Bailliere's, New York, $2,00.

A. Moreau de Jonnès: *Statistique de l'Industrie de la France.* 8vo, xxiv and 380 pp. Paris, 1856.

G. A. Chatin: *Anatomie Comparée des Végétaux;* Comprenant (1) les Plantes Aquatiques; (2) les Plantes Aeriennes; (3) les Plantes Parasites; (4) les Plantes Terrestres. 2nd and 3d Livraisons. 4to. Paris, 1856. Will be completed in about 20 numbers, each containing 3 leaves of text and 10 plates.

E. Cosson: *Rapport sur un Voyage Botanique en Algerie*, de Philippeville a Biskra et dans les Montes Aures, entrepris en 1853. 8vo, avec un planche. Paris, 1856.

Archives du Museum d'Histoire Naturelle. 8th volume, 4to, with 34 plates. Paris, 1856.—One volume is issued annually.

M. Roret: *Nouveau Manuel Complet du fabricant d'Etoffes* imprimées et du fabricant des papiers peints, par L. S. le Normand. 18mo. Paris, 1856.—Also other works on related subjects.

Pelouze et Fremy: *Traité de Chimie Generale*, comprenant les applications de cette science à l'Analyse Chimique, à l'Industrie, à l'Agriculture, et à l'Histoire Naturelle. 2me edit. Tome 5. Paris, 1856.—Another volume will complete the work.

M. A. Becquerel: *Des Applications de l'électricité à la Pathologie.* 8vo. Paris, 1856.

F. Malaguti: *Leçons de Chimie Agricole professées en* 1847. 18mo. Paris, 1856.

Proceedings Bost. Soc. Nat. History, Vol. V, July, 1856.—Page 337, On a factitious product alleged to have been taken from the jaw of the Musk Ox; *J. Wyman.*—p. 338, Note on two Fungi, *Spilocæa fructigena* and *Asteroma pomigena; C. J. Sprague.*—p. 339, Analyses of Serpentine Rock; *A. A. Hayes*, followed by remarks by *C. T. Jackson* and *W. B. Rogers.*—p. 349, On the Monks Island Guano; *A. A. Hayes.*—p. 355, Narraganset artificial fish-guano; *C. T. Jackson.*—p. 359, Death of Dr. Warren.—p. 363, Appointment of officers for the ensuing year: C. T. Jackson, M.D. and D. Humphreys Storer, M.D., Vice Presidents; S. L. Abbott, M.D., Corresponding Secretary; B. S. Shaw, M.D., Recording Secretary; N. B. Shurtleff, M.D., Treasurer; C. K. Dillaway, Librarian.—p. 364, Origin of Greensand and its formation in the oceans of the present epoch; *J. W. Bailey.*

Proceedings of the American Phil. Soc. Philadelphia. Vol. VI. Jan.—June, 1856, No. 55.—p. 167, Officers for the year: A. D. Bache, President, J. K. Kane, R. Dunglison, J. F. Frazer, Vice Presidents, C. B. Trego, E. O. Kendall, F. Fraley, J. L. LeConte, Secretaries.—p. 169, Improved carpenter's square; *Rev. Dr. Rogers.*—p. 179, Skater's reel; *Peale.*—p. 184, New specimens in the U. S. Mint; *DuBois.*—p. 186, Plants of the Arctic; *Durand.*—p. 189, Monks Island Guano; *A. S. Piggot.*—p. 193, 201, Apparatus for taking specific gravities; *Eckfeldt* and *Dubois.*